

The Wind Erosion Prediction System

WEPS 1.0

User Manual DRAFT

USDA-ARS Wind Erosion Research Unit Manhattan, Kansas, USA

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Preface and Acknowledgments

Preface

Wind erosion is a serious problem on agricultural lands throughout the United States as well as the world. The ability to accurately predict soil loss by wind is essential for, among other things, conservation planning, natural resource inventories, and reducing air pollution from wind blown sources. The Wind Erosion Equation (WEQ) is currently widely used for assessing average annual soil loss by wind from agricultural fields. The primary user of WEQ is the United States Department of Agriculture, Natural Resources Conservation Service (USDA-NRCS). When WEQ was developed more than 35 years ago, it was necessary to make it a simple mathematical expression, readily solvable with the computational tools available. Since its inception, there have been a number of efforts to improve the accuracy, ease of application, and range of WEQ. Despite these efforts, the structure of WEQ precludes adaptation to many problems.

The USDA appointed a team of scientists to take a leading role in combining the latest wind erosion science and technology with databases and computers, to develop what should be a significant advancement in wind erosion prediction technology. The Wind Erosion Prediction System (WEPS) incorporates this new technology and is designed to be a replacement for WEQ.

Unlike WEQ, WEPS is a process-based, continuous, daily time-step model that simulates weather, field conditions, management, and erosion. WEPS 1.0 consists of the WEPS science model with a user friendly interface that has the capability of simulating spatial and temporal variability of field conditions and soil loss/deposition within a field. WEPS 1.0 can also simulate simple field shapes and barriers on the field boundaries. The saltation/creep, suspension, and PM10 components of eroding material also can be reported separately by direction in WEPS 1.0. WEPS 1.0 is designed to be used under a wide range of conditions in the U.S. and is adaptable to other parts of the world. For further information regarding WEPS contact:

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The contribution of the NRCS state and field offices and other individuals who participated in the WEPS validation studies is also recognized.

Finally, acknowledgment is made of the many other individuals who have made this release of WEPS possible by reviewing this document and those who contributed through fundamental research on which many of the underlying concepts of WEPS are based.

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INTRODUCTION



Introduction

How to Use This Document

The Wind Erosion Prediction System or 'WEPS' is a process based, daily time-step, wind erosion simulation model. It represents the latest in wind erosion prediction technology and is designed to provide wind erosion soil loss estimates from cultivated, agricultural fields. WEPS 1.0 consists of the computer implementation of the WEPS science model with a graphical user interface designed to provide easy to use methods of entering inputs to the model and obtaining output reports. WEPS was developed by the Wind Erosion Research Unit (WERU) of the United States Department of Agriculture, Agricultural Research Service.

The WEPS 1.0 User Manual is designed to provide information to different levels of users. Those users who are completely new to WEPS should start by reading all of this chapter to get an introduction to WEPS. It is recommended that, as a minimum preparation to use WEPS, the user should read the "Overview of the Wind Erosion Prediction System".

The minimum computer requirements and the steps to install WEPS onto your computer are described in this chapter. Once WEPS has been installed on your computer, the user should learn how to make a simple simulation run using the "Quick Start for WEPS 1.0". More experienced users should become familiar with the "Interface Reference - How to Operate WEPS", which goes into detail of how to use all of the capabilities of WEPS 1.0. These details are also available in the 'Online Help', accessible through the toolbars on the WEPS 1.0 interface screen.

"Using WEPS in Conservation Planning" contains sections on 'Interpreting Outputs', 'Special Field Configurations', and 'Using Barriers for Erosion Control in WEPS'. This section also has Example problems which guides the user through exercises that describe how to use WEPS to design conservation systems.

An index to the WEPS User Manual is also available. Finally, the "Appendices" contains information for more advanced users. For users interested in more details on the interface and science behind WEPS, Appendix 1, titled 'Interface Implementation and Science Model' is recommended. An even more detailed description of the science of the WEPS model is available in the "WEPS Technical Description" which can be obtained from WERU.

The Appendix also contains information for more advanced users such as the WEPS 'Databases' and a listing of 'Submodel Report Flags and Command Line Options'. Databases are described for the Weather, Soil, Crop, Management, and Operations sections of WEPS. Submodel Report Flags and Command Line Options are set under the 'Configurations' tabs available through the Main Screen of the interface. Certain permissions may be required to

alter some of these flags and options. There is an appendix on "Using WEPS with Measured Data" which will be useful to researchers and other users such as those outside the US who do not have their soils data in the SSURGO database format.

Throughout this manual, the term "user" refers to the person(s) using WEPS 1.0 to set up and make a simulation run. "Operator" refers to the producer or land manager whose actual field is being simulated with WEPS. This manual contains many graphics which are examples of what can be seen on the computer screen using WEPS. In addition, WEPS will continually be improved and the screens may change. Therefore, the user may or may not see the exact same screens as those illustrated in this manual.

WEPS is a model developed primarily for use by the USDA, Natural Resources Conservation Service (NRCS). As such, many of the capabilities of WEPS reflect the needs of NRCS for use in cultivated agricultural systems. However, WEPS has capabilities to be used in other situations where wind affected soil movement is a problem. Contact WERU if you wish to use WEPS to predict erosion for situations other than traditional cultivated agricultural systems.

Minimum Computer Requirements

The minimum recommended requirements to install and operate WEPS 1.0 effectively are: A personal computer (PC) with Windows 95/98 (48 Mb RAM), Windows NT (64 Mb RAM), Windows 2000 (192 Mb RAM), or Windows XP (256 Mb RAM); 300 MHz Pentium; 150 Mb free disk space on the hard drive; a CD-ROM drive for installation; and a VGA color monitor with a minimum screen resolution if 800 x 600 pixels. Contact WERU if you need assistance.

Installation

For Windows operating systems, insert the WEPS 1.0 CD into the CD-ROM drive. Click [Start] [Run] and enter {w:/setup} where "w" represents the drive letter for your CD-ROM drive. Follow the instructions on the screen. NOTE: See the "readme" file for up-to-date installation instructions for this CD-ROM. Note that on Windows NT, 2000, and XP machines, the user must either be logged in as "administrator" or have sufficient privileges to successfully install WEPS 1.0. The WEPS install program will inform the user attempting installation if they do not have sufficient privileges to perform the installation.

WEPS1.0 is also available for download on the WERU web site at http://www.weru.ksu.edu/weps. Follow the link for the WEPS download and fill out the WEPS Download Registration form. By filling out the registration form, WERU will provide notices of updates to the model. The download file consists of an executable file which will install WEPS onto your Windows computer. Contact WERU if you need assistance at:

Phone: 785-537-5559

E-mail: weps@weru.ksu.edu.

An Overview of the Wind Erosion Prediction System

Introduction

The Wind Erosion Prediction System (WEPS) is a process-based, daily time-step model that simulates weather, field conditions, and erosion. WEPS development was in response to customer requests for improved wind erosion technology. It is intended to replace the predominately empirical Wind Erosion Equation (WEQ) (Woodruff and Siddoway, 1965) as a prediction tool for those who plan soil conservation systems, conduct environmental planning, or assess offsite impacts caused by wind erosion.

WEPS development involves an ARS led, national, multi-disciplinary team of scientists. It has a multi-agency commitment consisting of the Agricultural Research Service (ARS), Natural Resource Conservation Service (NRCS), and Forest Service (FS) from the U.S. Department of Agriculture, along with the Environmental Protection Agency (EPA), the U.S. Army Corps of Engineers, and Bureau of Land Management (BLM).

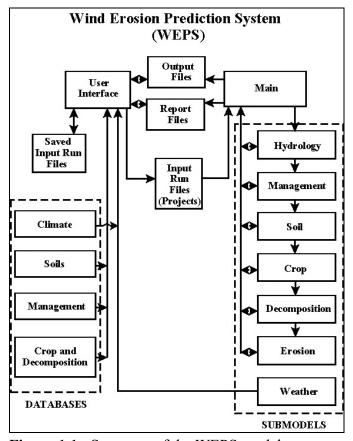


Figure 1.1. Structure of the WEPS model.

Objectives

The purposes of WEPS are to improve assessment of soil loss by wind from agricultural fields and to provide new capabilities such as assessing plant damage, calculating suspension loss, and estimating PM-10 emissions from the field.

Background

Soil erosion by wind is initiated when the wind speed exceeds the saltation threshold speed for a given soil and biomass condition. After initiation, the duration and severity of an erosion event depend on the wind speed and the evolution of the surface condition. Because WEPS is a continuous, daily time-step model, it simulates not only the basic wind erosion processes, but also the processes that modify a soil's susceptibility to wind erosion.

The structure of WEPS is modular and consists of a user-interface, a science model including seven submodels, and four databases (Fig. 1.1). The user-interface is used to create input files using information from the databases and the weather generator. In a practical application, new input files will usually be created by using previous input files as templates modified within the user-interface.

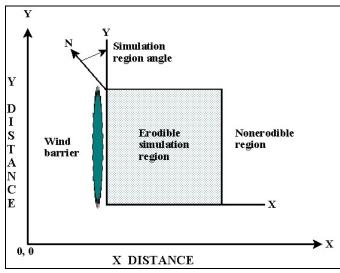


Figure 1.2. WEPS simulation geometries.

Simulation Region

In WEPS, the simulation region is a field (Fig. 1.2). Users must input the geometry of the simulation region. Initial conditions must also be specified for the surface and soil WEPS can output soil layers. loss/deposition over selected time intervals from the simulation region. WEPS also provides users with individual soil loss components of creep-saltation, suspension, and PM-10 size fractions. The soil loss components are particularly useful as an aid in estimating off-site impacts of wind erosion.

Discrete Time and Space

The time step is controlled within the main program. To reduce computation time, a daily time step is used in WEPS, except for selected subroutines in the HYDROLOGY and EROSION submodels, which use hourly or sub-hourly time steps. Submodels are called by the MAIN program (Tatarko, 1995) in the order shown in Fig. 1.1. Each individual submodel controls the sequence of calculations within itself. However, in MANAGEMENT, field operations are simulated sequentially according to the order in which they appear in the management plan when more than one crop is grown in a planned sequence. Management plans usually cover at least a single year and may cover multiple years. WEPS simulates conditions and soil loss on homogeneous simulation regions. "Homogeneous" means that the soil type, biomass, and management are similar over a subregion.

Weather Simulated from Climate Databases

WEPS requires wind speed and direction to simulate the process of soil erosion by wind. These and other weather variables are needed to drive temporal changes in hydrology, soil erodibility, crop growth, and residue decomposition in WEPS. The weather generator consists of the programs WINDGEN and CLIGEN (Tatarko et al., 1995).

WINDGEN simulates wind speed and direction for WEPS (Skidmore and Tatarko, 1990; Wagner et al., 1992). It was developed specifically for use with WEPS and stochastically (i.e., randomly based on historical weather) simulates wind direction and sub-daily wind speeds. A compact database (Skidmore and Tatarko, 1990, 1991) developed for WINDGEN was derived from historical monthly summaries of wind speed and wind direction contained in the Wind Energy Resource Information System (WERIS) database at the National Climatic Data Center in Asheville, North Carolina.

CLIGEN is the weather generator developed for the Water Erosion Prediction Project (WEPP) erosion model (Nicks et al., 1987). It is used with WEPS to generate an average annual air temperature as well as daily precipitation, maximum and minimum temperatures, solar radiation, and dew point temperature. Average daily air temperature and elevation for the site are used to calculate average daily air density within WEPS. Air density is an important factor in clculating wind energy available for erosion. CLIGEN and its database are described fully in the WEPP documentation (Nicks and Lane, 1989).

Field Conditions Simulated

The HYDROLOGY submodel (Durar and Skidmore, 1995) estimates soil surface wetness; accounts for changes in soil temperature; and maintains a soil-water balance based on daily amounts of snow melt, runoff, infiltration, deep percolation, soil evaporation, and plant transpiration. Snow melt depends on maximum daily air temperature and initial snow water content. Runoff is calculated from rainfall rate greater than infiltration, adjusted for ponding and surface flow velocity. Water is infiltrated and distributed according to Darcy's Law. Potential evapotranspiration is calculated using a revised combination method of Van Bavel. Total daily potential evapotranspiration then is partitioned, based on crop leaf area index, into potential soil evaporation and plant transpiration. Hourly potential soil evaporation rates are estimated from the daily value based on soil water availability.

A soil's aggregation and surface state can dramatically affect susceptibility to wind erosion. Thus, changes in soil and surface temporal properties are simulated daily by the WEPS SOIL submodel (Hagen et al., 1995b) in response to various weather processes like wetting/drying, freeze/drying, freeze/thawing, precipitation amount and intensity, and time. Soil layer properties such as bulk density, aggregate size distribution, and dry aggregate density are maintained on a daily basis. Surface properties, such as random and oriented roughness; crust generation, coverage fraction, density, stability, and thickness; and loose erodible material on crusted surfaces also are accounted for in the SOIL submodel.

The presence of live or dead biomass on the soil surface influences the quantity of soil that can be removed by wind erosion. Therefore, the CROP submodel (Retta and Armbrust, 1995) simulates the growth of crop plants. The crop growth model was adapted from the Erosion Productivity Calculator (EPIC) crop growth model (Williams et al., 1990), which simulates a variety of crops and plant communities while accounting for water stresses. It

calculates daily production of masses of roots, leaves, stems, and reproductive organs and also leaf and stem areas. Additional capabilities and modifications have been incorporated into the CROP submodel to meet the need for predicting effects of a growing crop on wind erosion. Some of the factors that affect wind erosion are the flexibility and arrangement of individual plant parts, distribution of plant parts by height, and number of plants per unit area (Shaw and Periera, 1982). Thus, leaves and stems are accounted for separately because: 1) stems of young seedlings are roughly 10 times more effective than leaves, on a per-unit-area basis, in depleting wind energy; 2) leaves are more sensitive to sandblast damage than are stems; and 3) decomposition rates of stems and leaves are different.

The DECOMPOSITION submodel (Steiner et al., 1995) for WEPS simulates the decrease in crop residue biomass from microbial activity. The decomposition process is modeled as a first order reaction, with temperature and moisture as driving variables. Standing residue is significantly more effective than flat residue at reducing wind energy at the soil surface. Hence, it is maintained separately from flat residue, and the conversion from standing to flat is simulated. The quantities of biomass remaining after harvest are partitioned into standing, surface, buried, and root pools with below ground biomass decomposition calculated for each soil layer. Because crop residue decomposition varies by type and changes with residue age, each pool is subdivided further into 1) the most recently harvested crop pool, 2) the next-to-last crop pool, and 3) a "generic" crop pool that contains all older residue mass.

WEPS is expected to reflect the effects of various management practices upon wind erosion, and that is done by the MANAGEMENT submodel (Wagner and Ding, 1995). All major management operation classes are represented, such as primary and secondary tillage, cultivation, planting/seeding, harvesting, irrigation, fertilization, and burning. Each individual operation is simulated within the MANAGEMENT submodel as a series of physical processes. Those processes include 1) soil mass manipulation (changes in aggregate size distribution, soil porosity, mixing soil and residue by depth, and soil layer inversion); 2) surface modification (creation or destruction of ridges and/or dikes that form oriented surface roughness, changes in surface random roughness, and destruction of surface crusts); 3) biomass manipulation (burying and resurfacing residue, cutting standing residue, flattening standing residue, killing live crop biomass, and biomass removal); and 4) soil amendments (residue addition, planting, and irrigation).

Erosion Processes Simulated

The EROSION submodel (Hagen, 1995) decides if erosion can occur based on the current soil surface roughness (oriented and random), flat and standing biomass, aggregate size distribution, crust and rock cover, loose erodible material on a crust, and soil surface wetness. If the maximum daily wind speed reaches 8 m/s at 10m and snow depth is less than 20mm, the surface condition is evaluated on a sub-hourly basis to determine if erosion can occur. The EROSION submodel simulation performs the following functions: 1) calculates friction velocities based on the aerodynamic roughness of the surface, 2) calculates static threshold

friction velocities, 3) computes soil loss/deposition within each grid cell, and 4) updates soil surface variables to reflect changes in soil surface "state" caused by erosion.

Summary Comparison of WEPS and WEQ

Users of wind erosion prediction technology encounter a wide range of challenging environmental problems that require solutions. WEQ was unable to meet some of these needs. After extensive consultations with users, the WEPS structure was designed with the capabilities to meet the needs identified. As such, WEPS represents new technology and is not merely an improvement and recoding of WEQ technology. Also, WEPS contains many simplifications to maintain reasonable computation times. Because many users are familiar with WEQ, a brief comparison of WEPS and WEQ follows to facilitate understanding of WEPS modeling techniques.

WEQ predicts average erosion along line-transects across the field, whereas WEPS treats the field as two-dimensional. The WEPS EROSION submodel simulates soil loss/deposition for grid areas over the entire simulation region. This feature allows users to "look inside" by specifying arbitrary accounting regions within the simulation region and, thus, obtain results averaged over selected grid areas within the accounting region (not available in WEPS 1.0).

WEQ predicts only long-term, average, soil loss. WEPS calculates on a daily basis and allows users to specify the output intervals. Thus, users can obtain outputs ranging from single storms to multiple years. By simulating for multiple years, the probability of various levels of erosion during any period of a rotation also can be determined.

The largest contrast between the two technologies is that WEPS simulates a wide range of processes to describe field surface conditions and wind erosion, whereas WEQ depends on users to input correct estimates of the field surface conditions. Unfortunately, erosion does not vary linearly with residue cover and other temporal field conditions. Therefore, simply specifying average field conditions as inputs likely will not yield the best estimates of long-term average erosion.

The WEQ contains no feedback loop that modifies the field in response to weather or erosion. In WEPS, the driving forces of weather cause surface temporal properties of the field to change. Thus, in a year with high rainfall, the field soil roughness may be reduced below average, while above average biomass production prevents erosion. However, in a drought year, biomass and aggregate size may both be below average, but tillage ridges may then be the primary control against soil erosion.

The modeling techniques used to simulate processes in WEPS vary. The WEATHER submodel generates stochastic simulated weather variables. Mechanistic and statistical relations are used to represent processes in the other submodels. However, a structured design methodology was used. First, the major wind erosion processes, such as emission,

abrasion, and trapping were identified. Next, the individual temporal soil and biomass properties that affect the wind erosion processes were selected. Then, WEPS submodels were designed to simulate the general processes that control both the surface temporal properties and the erosion processes. Finally, parameters from the databases were used to make the simulation of various processes unique for specific soil, crop, and management actions.

Implementation

The current WEPS model is coded in FORTRAN conforming to the ANSI FORTRAN 77 and Fortran 95 standard. The coding guidelines used, with some minor modifications for WEPS, are outlined in the "Water Erosion Prediction Project (WEPP) Fortran-77 Coding Convention" (Carey et al., 1989). The model can be run in a Windows, Unix, or Linux environment. WEPS science code and implementation is documented fully in the WEPS Technical Description (Hagen et al., 1995a).

WEPS Updates

The WEPS model is continually being improved with periodic updates. The USDA-ARS Wind Erosion Research Unit (WERU) has established several means for obtaining the latest release of the WEPS model, databases, documents, and other related information as they become available.

For users with Internet access, WERU has established a World Wide Web site. The URL for WEPS downloads is: http://weru.ksu.edu/weps. This site contains all the information on WEPS. Specific WEPS information also can be obtained through E-Mail at: weps@weru.ksu.edu.

Users without Internet access can obtain WEPS update information by contacting:

USDA-ARS, NPA Wind Erosion Research Unit 1515 College Avenue Manhattan, KS 66502

Phone: 785-537-5559 FAX: 785-537-5507

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Quick Start for WEPS 1.0

WEPS is a comprehensive wind erosion model with many options for inputs and outputs. However, for basic simulations, WEPS is simple to operate. The following quick start guide will describe how to make a simple simulation run.

To start WEPS, double left click on the Weps1.0 icon on the computer screen 'desktop' Note: the NRCS standard is to start WEPS from the 'Start Menu' (e.g., "Start>Programs>USDA Applications>WEPS>WEPS 1.0"). The WEPS 1.0 main screen will then appear.

A Simple Simulation

For a simple simulation, only four types of information are entered on the main screen.

- 1. Describe the simulation field geometry by selecting the field dimensions and field orientation in the panel labeled "Simulation Region Information".
 - a. Type in the specific X-Length and Y-Length field dimensions.
 - b. Enter the specific field orientation (±45° max) relative to true north, in the "Orientation" box.
- 2. Select a field location (for weather files).
 - a. In the panel labeled "Location Information", use the mouse to select a State and County from the drop down menus

 The closest weather stations to the center of the selected county will be loaded.
- 3. Select a soil.
 - a. In the bottom panel of the window, to the right of the button labeled 'Soil', use the mouse to select a soil from the drop down "Template" menu 1.
- 4. Select a management scenario.
 - a. In the bottom panel of the window labeled 'MCREW', use the mouse to select a crop rotation from the drop down "Template" menu 7.

Once these items are complete, click the 'Run' button on the tool bar at the top of the screen. You will be asked to enter a name for the simulation run and click 'OK'. Once a run name is entered, you will then see indicators that WEPS 1.0 is running. When the simulation run is finished, the "WEPS Project Summary" screen will appear.

WEPS Project Summary

The Project Summary displays user information, input parameter files, and basic soil loss information by rotation year and the average annual for the total simulation. Soil loss output in the Project Summary includes: *Gross Loss* which is the average erosion within the field; *Total* which is the average total net loss from the field; *Creep/Salt* which is the average creep plus saltation net loss from the field; *Suspension* which is the average suspension net loss from the field; and *PM10* which is the average net loss of particulate mater less than 10 microns in size from the field.

Exiting WEPS 1.0

To exit WEPS 1.0, click "Project" on the menu bar at the top of the main screen, then click "Exit". You will be asked if you want to save your project. You will also be asked to confirm if you really want to exit WEPS 1.0.

Additional Information

WEPS has the capability for many simulation input options including adding barriers, and specifying numerous management options. WEPS also can optionally produce very detailed output to provide the user with a better understanding of what field conditions and management situations cause soil loss by wind. Consult the WEPS 1.0 User Manual for complete details. For further information regarding WEPS contact:

USDA-ARS Wind Erosion Research Unit 1515 College Avenue Manhattan, Kansas 66502

Phone: 785-537-5559

E-mail: weps@weru.ksu.edu

Web: http://www.weru.ksu.edu/weps

INTERFACE REFERENCE



WEPS Interface Main Screen

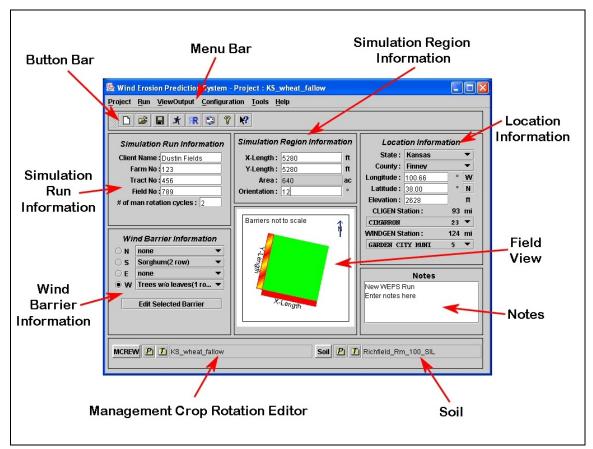


Figure 2.1. Main screen of the Wind Erosion Prediction System.

The WEPS main screen (Fig. 2.1) should appear at the model startup. Each part of the main screen is labeled in the Figure with regard to its function. A brief description of each part is given below. More detailed descriptions of their functions and use follow later in this chapter.

- The **Button Bar** and **Menu Bar** are collectively referred to as Toolbars. The Menu Bar provides the user with access to many of the operational functions of WEPS. The Button Bar provides a shortcut way of executing some of the Menu Bar functions.
- The **Simulation Run Information** panel is used to enter customer information for a simulation run as well as information regarding the run length. The customer information is for information only and is not critical to the operation of WEPS.
- The **Simulation Region Information** panel provides the physical dimensions (i.e.,

length and width) as well as the orientation of the simulation field.

- The **Location Information** panel is used to specify the location of the simulation field. This information is used to assist in determining the climate and wind stations selected for the simulation.
- The properties and placement of barriers on the field borders is entered in the **Wind Barrier Information** panel.
- The **Field View** panel displays the physical dimensions and orientations of the field and barriers. This panel is for information only and is not editable.
- User **Notes** can be entered in the lower right of the screen. These notes are retained as part of the project and can be printed from the Output Summary form.
- Access to the **Management/Crop Rotation Editor** for WEPS (MCREW) allows for the selection, creation, and editing of management scenarios.
- The **Soil** panel is used to select and view the soil information for the simulation. Only one soil is allowed for the WEPS simulation region.

Toolbars

Menu Bar

Project Run ViewOutput Configuration Tools Help

This is the top line of the WEPS main screen. A description of each item on the menu bar is given below.

Project Project

The 'Project' menu is a drop down list of various computer operations pertaining to WEPS projects. The Project menu contains the following options:

- ► New allows user to create a new project from scratch (Ctrl-N).
- Open... allows user to open an existing project (Ctrl-O).
- Save saves the currently displayed project to its current file name (Ctrl-S).
- Save As.. saves currently displayed project under a different file name.
- **Delete Project** opens a file chooser to delete a WEPS project (Ctrl-P).
- ▶ **Delete Run** opens a file chooser to delete a WEPS run (Ctrl-P).
- **Exit** exit the WEPS program (Ctrl-X).

Run

This allows the user to run WEPS using the current inputs specified on the main screen WEPS window or to restore inputs from previous WEPS Runs. The 'Run' menu on the WEPS Main Screen brings up the following options:

- 'Make a WEPS Run' begin a WEPS simulation using the current selected inputs.
- *Make a Yield Calibration WEPS Run' begins a WEPS simulation running WEPS in "yield calibration mode". See section titled "Making a WEPS Run" for more information on calibration runs.
- * 'Restore a WEPS Run' reloads the inputs used in a previous WEPS run.

ViewOutput

This menu allows the user to view output for the current (most recent) and previous WEPS runs.

- 'Current Run' clicking on this menu item opens a list of output options.
 - 'Project Summary' displays a brief output summary for the most recent WEPS run (Ctrl+Shift-P).
 - **'Crop Summary**' displays a summary of yield parameters for the most recent WEPS run (Ctrl+Shift-Y).
 - <u>'Management Summary'</u> displays a summary of management operations for the most recent WEPS run (Ctrl+Shift-M).
 - '<u>Detailed Reports</u>' displays a detailed output for the most recent WEPS run (Ctrl+Shift-R).
 - **'Debugging Reports'** displays a screen to view additional output files from the most recent WEPS run (Ctrl+Shift-O).
- <u>Previous Run</u>' clicking on this menu item opens the following list of output options.
 - 'Project Summary' open a brief output summary of a previous WEPS run (Ctrl+Alt-P).
 - **'Crop Summary'** open a summary of yield parameters for a previous WEPS run (Ctrl+Alt-Y).
 - '<u>Management Summary</u>' open a summary of management operations for a previous WEPS run (Ctrl+Alt-M).
 - '<u>Detailed Reports</u>' open the detailed output for a previous WEPS run (Ctrl+Alt-R).
 - '<u>Debugging Reports</u>' Display a screen to view additional output files from a previous WEPS run (Ctrl+Alt-O).

Configuration

The 'Configuration' menu currently has only one item, 'Edit Configuration' which brings up a tabbed window with various configuration options for WEPS.

- 'Miscellaneous' opens a tab that allows the user to set the following:
 - Display either Metric or English units on WEPS screens.
 - Enter the number of time steps used for the daily distribution of simulated wind speed.
 - Check box to display the latitude and longitude fields in the 'Location Information' panel on the Main screen. Un-check the box to hide these fields.
 - Check box to display the state and county fields in the 'Location Information' panel on the Main screen. Un-check the box to hide these

fields.

- Check box to display the 'Use Map' button in the 'Location Information' panel on the Main screen. Un-checking the box, hides this button.
- Maximum search radius for the climate station choice lists (kilometers or miles, depending upon the "Measurement Units" setting). Usually the user will want the nearest station to their simulation site. However, the user may want to select a different station which is more typical of the climate for the field being simulated, if the nearest station doesn't meet their criteria. An example of not selecting the closest station might occur in mountainous areas where the nearest station does not always typify the climate for the simulated field.
- Tooltip delays sets the delay time for the initial appearance of the tooltip and for the dismissal of the tooltip box from the screen. The units are in milliseconds. To disable tooltip display, set the "Initial" value to 1000 (1 second) and the "Dismiss" value to zero.
- **Output**' opens a tab that allows the user to set the following output options:
 - Reporting period for detailed submodel reports.
 - Flags for submodel reports which give model developers and advanced users more detailed output than is available through the interface. See the Appendix for flag numbers to set for submodel reports.
- **'Email'** opens email configuration settings:
 - Sender Addr enter the default email address of the sender.
 - SMTP Server enter your mailhost SMTP server address.
 - Comments default recipient for comments to WEPS developers.
 - Bugs default recipient for a bug report.
- 'Run' opens a tab with run options:
 - Run Length Mode click a button to select a type of run length as either the NRCS method (which specifies a fixed number of cycles and is required for all "official" NRCS WEPS runs), use simulation run start and end dates on the main screen, or specify the use of rotation cycles on the main screen.
 - Alternative weather files click the check box next to the name of a weather file type to use alternative weather files (e.g. measured wind data). The user will then be able to enter the file name and path or browse for the file by clicking the folder icon on the main screen.
- **Executables**' opens a tab that allows the user to select executable files and command line arguments (see Appendix of the WEPS User Manual for the command line argument definitions):
 - WindGen.exe enter the path and file name for the default Windgen executable.
 - WindGen cmd enter the default Windgen command line arguments (see Appendix for argument list).

- CliGen.exe enter the path and file name for the default Cligen executable.
- CliGen cmd enter the default Cligen command line arguments (see Appendix for argument list).
- WEPS exe enter the path and file name for the default WEPS executable.
- WEPS cmd enter the default WEPS command line arguments (see Appendix for argument list).
- WEPS Cal. cmd enter the command line arguments to be used for a yield calibration run (see Appendix for argument list).
- 'Directories' opens a tab that allows the user to select the directories used for templates, skeleton files, databases, and projects:
 - Man Template default directory for the management templates.
 - Man Skeleton default directory for the management skeleton files.
 - Man Op DB default directory for the management operation database files.
 - Crop DB default directory for the crop database files.
 - MCREW Dir default directory for MCREW configuration files.
 - Soil DB Either the default directory for "ifc" soil database files or the name of a SSURGO Microsoft Access database file, including the path. If an "ifc" directory is entered, the 'Soil DB spec' field below should be left blank.
 - Soil DB spec the JDBC:OBDC driver specification for accessing SSURGO soil data in a Microsoft Access database file. This field should be left blank if the "Soil DB" field specifies a directory containing "ifc" soil files.
 - Projects Dir default directory for WEPS projects.

At the bottom of the Configuration panel are three buttons:

- ► <u>OK</u> saves the changes for the current running instance of the user interface only and closes the window.
- ► <u>Save</u> saves any changes made in the configuration window permanently to the WEPS configuration file.
- ► Help opens general help for the configuration window.

Tools

This menu contain various tools available for use with WEPS including:

Send Email' - send email comments to WERU, providing the computer is connected to the Internet and the email configuration options are properly configured. The user can also attach current WEPS project and run files to the messages.

Help

This menu contains help options for WEPS including:

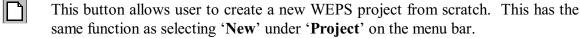
- 'About WEPS' displays the Build Date and Release Number for WEPS.
- 'Help Topics' displays a window containing the WEPS online help system.

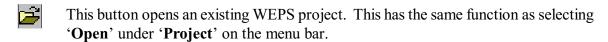
Button Bar

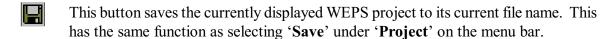


At the top of the main WEPS window (below the menu bar) is a series of buttons with icons, designed to help the user in the operation of WEPS.

Project Operations

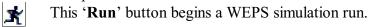




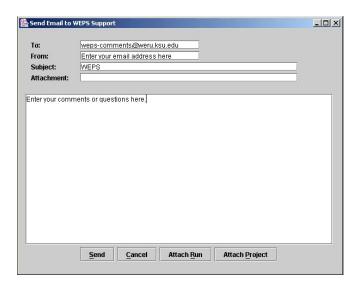


Run and Help

ЯR



This 'Reload' button allows the user to "restore the inputs from a previous WEPS run" into the main WEPS interface window.





This 'Email' button allows the user to email comments to WERU along with the contents of a WEPS project or WEPS run, if desired. Clicking the 'Email' button brings up a separate window (see below).

The user should enter their email address, if it has not been previously set in the configuration panel, and a short message. Click the appropriate box at the bottom of the window to select and attach a WEPS project and/or WEPS runto your email. See the 'Interface Reference: Making a WEPS Run' section in the User Manual for a description of WEPS projects and WEPS run files. If you are connected to the Internet and the email options are properly set in the configuration screen, clicking 'Send' will email the message to WERU, along with any attached files so that your inquiry can be answered.



This 'Question' button opens the general help system for WEPS.



This 'Context Help' button provides help for a particular item on the WEPS screen. Clicking the 'Context Help' button on the tool bar and then clicking on the item on the screen for which help is desired brings up a help screen for that specific item.

Field View and Barriers

Field View

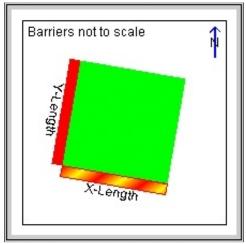


Figure 2.2. Field View Panel.

The Field View Panel (Fig. 2.2) is located in the center of the WEPS1.0 main screen. It is designed to give the user a view of the field size, shape, and orientation (green). The placement of any barriers present is also displayed (red). Note that if the ratio of length to width of the field or barriers is too great to display to scale, this will be indicated within the panel and an approximation of the field or barrier shape will be displayed. This panel is for viewing only and is not editable.

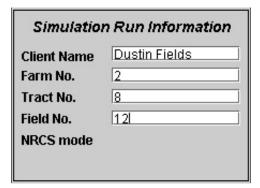


Figure 2.3. Simulation Run Information Panel.

Simulation Run Information

Customer information for a simulation run is entered by using the left panel of the WEPS1.0 main screen (Fig. 2.3) labeled 'Simulation Run Information'.

The Client Name as well as the Farm, Tract, and Field Number for the simulation run can be entered by typing the information in the appropriate box in the panel. Note that there are three options for run length type. The NRCS mode specifies a fixed number of cycles. This option is locked for official

NRCS field use. Other users can specify a simulation run start date and end date on the main screen, or specify the number of rotation cycles to use on the main screen. The length of run is controlled through the 'Run' tab on the 'Configuration' panel (see the discussion on 'Configuration' for more details).

Wind Barrier Information

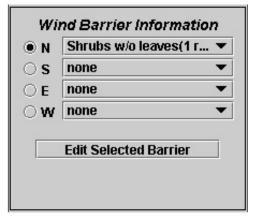


Figure 2.4. Wind Barrier Information panel.

The wind barrier panel (Fig. 2.4) is used to add barriers to the field borders. Note that WEPS1.0 only allows barriers on the borders of the field. The barrier for each field border is labeled 'N' for north, 'S' for south, 'E' for east, and 'W' for west. The barrier type can be selected from the drop down list in the panel by clicking the down arrow to the right of the barrier type to bring up the list of available barriers and clicking on the appropriate barrier. Once a barrier type is selected, the barrier properties may be viewed and edited by clicking the 'Edit Selected Barrier' button at the bottom of the panel. A separate panel is opened where one may enter the barrier width, height, and porosity in the

appropriate space. Note that the area of the barrier is displayed but cannot be edited. If barrier properties are modified, it will be noted in the type list with a '<mod>' designation before the type name. To remove a barrier from the field, click the radio button to select it (notice the barrier will be 'highlighted' when selected) then select the barrier type 'None' to remove it. To 'deselect' all barrier locations, click the enabled radio button off.

Simulation Region Information

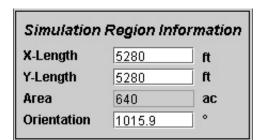


Figure 2.4. Simulation Region Information panel.

The 'Simulation Region Information' panel is shown in Figure 2.4. To describe the simulation region, the field dimensions are entered as an X-Length and a Y-Length. Note that the area of the region will be displayed but can not be edited. To orient the field direction, simply type in the angle in degrees of deviation from north of the field and click 'Enter'. Note that the field will only rotate in a range of ± 45 degrees. By rotating and adjusting the field length and width, the user should be able to

obtain the desired field size and orientation for a rectangular field. Creating special shapes or configurations such as circles and strip cropping are discussed under "Using WEPS for Conservation Planning".

Choosing a Location

Choosing a location within WEPS defines the physical location of the field to be simulated. This location information is used within WEPS to select the weather stations (CLIGEN and WINDGEN) to be used for the simulation.

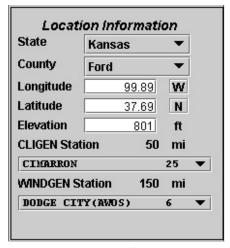


Figure 2.5. 'Location Information' Panel.

Location information is entered through the rightmost panel labeled 'Location Information' on the main interface screen (Fig. 2.5). Select the state and county of interest from the drop down list by clicking the down arrow to the right of the state and county. The centroid latitude and longitude coordinates of the county will automatically be displayed. The CLIGEN and WINDGEN stations nearest to the center of the selected county will then be selected by the interface and displayed. Alternatively, the longitude and latitude of the location can also be entered, which will automatically display the state and county that the coordinates reside and select the nearest CLIGEN and WINDGEN stations to that location. Clicking the buttons to the right of the Longitude and Latitude fields will toggle between the Western w and Eastern

hemisphere for Longitude and the Northern N and Southern hemisphere for Latitude. Note that the default hemispheres are the Northern and Western hemispheres for the United States. If Southern hemisphere is desired, the user should select CLIGEN stations and management files appropriate for this hemisphere. Once the stations are displayed, the user can click on the down arrow next to the stations to bring up a list of nearby stations from which to choose an alternative station if desired. The State and County as well as the Longitude and Latitude fields are optional and can be added to or removed from the interface through the 'Miscellaneous' tab of the 'Configuration' panel (see the discussion on 'Configuration' for more details).

Notes

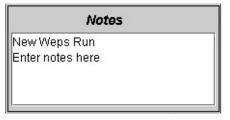


Figure 2.6. 'Notes' Panel.

The user may also type in notes for the run in the 'Notes' panel (Fig. 2.6). These notes will be displayed and can also be edited on the Project Summary output report after a WEPS run has been completed.

Choosing and Editing a Management Rotation

Management rotation scenarios for a simulation run can be selected or a rotation editor can be opened by using the 'MCREW' button on the left side of the bottom panel of the WEPS main screen (Fig 2.7).



Figure 2.7. Bottom panel of the WEPS main screen with the management box on the left.

A management rotation for a WEPS simulation run can be selected from pre-generated management files. Click the template folder in the management box which is located in the bottom panel of the main screen (Fig. 2.7) and then select the management rotation desired from the template directory. Once selected, the name of the management file will appear in the panel. The user may also select management files stored in the current WEPS project directory by clicking on the project folder . Usually, management rotation files in a WEPS project are derivatives of those selected from the "Template" directory with local "project specific" modifications. To open the Management/Crop Rotation Editor for WEPS (MCREW), double click on the 'MCREW' button MCREW , on the left side of the management box. This will open the MCREW window (Fig. 2.8), which allows the user to view, edit, and save management rotation information.

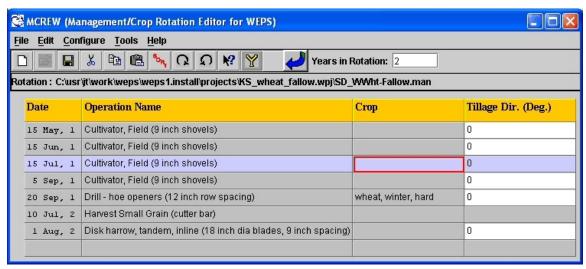


Figure 2.8. Management/Crop Rotation Editor for WEPS (MCREW) window.

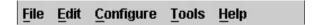
MCREW's principle purpose is to create/modify/construct management rotation files required for making WEPS simulation runs. Although it is an integral component of the WEPS 1.0 interface, it can be used as a stand alone program to edit management rotation files independent of the WEPS interface and was designed to be configurable for uses outside of WEPS. Much of MCREW's functionality, behavior and visual appearance is controlled via ASCII XML-based configuration files. Changing the appropriate configuration files allows one to specify the structure and definition of the management/crop rotation file format and the user's ability to view and edit specific operation and/or crop properties, etc.

MCREW is fundamentally a date-ordered list of management operations. This release of MCREW provides the user with a tabular, row-oriented view of the operations and their associated dates. In WEPS, a management operation is defined as any human initiated process, such as a tillage event, seeding, irrigation setting, etc. If the operation triggers the WEPS model to start simulating the growth of a crop (or any other plant vegetation supported with a crop database record containing the necessary vegetation growth parameters), e.g. a planting/seeding/transplanting operation, then the name of that crop is listed in the same row in the column next to the name of the operation.

Using MCREW

MCREW is designed to allow easy creation and editing of management rotation files for WEPS. The MCREW screen consists of 5 major components:

1. Menu bar



The menu bar consists of assorted menu options which provide access to MCREW's functions. Functions of the menu bar are discussed later in this document.

2. Button bar



The Button toolbar consists primarily of buttons that provide quick access to some of MCREW's most common functions. Functions of the buttons are discussed later in this document.

3. Years in Rotation

Years in Rotation:	2	

On the right of the button bar, the user may view and edit the number of years in a rotation cycle.

4. Rotation

Dotation :	en	Sniffhoat Fallow man	
Rotation:	Dυ_	SpWheat-Fallow.man	

This window displays the name and full path of the management rotation file which is loaded. If the management rotation name is too large, a scroll bar is automatically provided so the user can view the entire rotation name.

5. Table View

Date	Operation Name	Crop	Tillage Dir. (Deg.)
15 May, 1	Cultivator, Field (9 inch shovels)		0
15 Jun, 1	Cultivator, Field (9 inch shovels)		0
15 Jul, 1	Cultivator, Field (9 inch shovels)		0
5 Sep, 1	Cultivator, Field (9 inch shovels)		0
20 Sep, 1	Drill - hoe openers (12 inch row spacing)	wheat, winter, hard	0
10 Jul, 2	Harvest Small Grain (cutter bar)		
1 Aug, 2	Disk harrow, tandem, inline (18 inch dia blades, 9 inch spacing)		0

The Table View displays the sequence of operations with their associated dates and any crops planted in a tabular format. Spreadsheet style editing functions are available to manipulate the order, selection, and removal of operations and/or crops, etc. More details of the editing functions of the Table View are given later in this section.

Opening and Saving MCREW files

In WEPS 1.0, there are two primary locations that management rotation files exist:

1. In the "Management Templates" directory.

This is the location that complete or partial (single or multi-crop year) management rotation files are kept. Files in this directory always show up on the management rotation selection choice lists. Typically, management

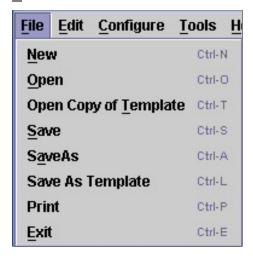
rotation files to be used in WEPS projects are selected from previously built management rotation files or are constructed from several partial management rotation files located in this directory.

2. Within a "WEPS Projects" directory.

Any edited or viewed management rotation file used in a WEPS project run is always located in that WEPS project's directory. There can be more than one management rotation file in a WEPS project. The current management rotation file to be used when making a WEPS run is the one specified in the "weps.run" file (e.g., the one listed in the "management" input field on the WEPS main screen. Usually, management rotation files in a WEPS project are simply copies of those selected from the "Template" directory with local "project or run specific" modifications.

Menu Bar Functions

File



Once the MCREW window is open, rotation files can be created from scratch, saved in the desired location and/or other rotation files opened for editing. The "File" menu contains all of these options, with the common functions ("New", "Open", and "Save") also being available on the icon button toolbar:

New Ctrl-N
 Opens an empty unnamed rotation file.

• Open Ctrl-O

Displays an "**Open File**" dialog box from which the user can select the desired rotation file from those in the current project. This is not accessible if the "Enable full MCREW editing functionality in WEPS" option is not enabled in the "Miscellaneous" tab of the WEPS interface Configuration panel.

• Open Copy of Template Ctrl-T

Displays an "Open File" dialog box from which the user can select the desired rotation file from the "Management Templates" directory. A copy of the selected file is then added to the current WEPS project and made available for editing in MCREW. This is not accessible if the "Enable full MCREW editing functionality in WEPS" option is not enabled in the "Miscellaneous" tab of the WEPS interface Configuration panel.

• Save Ctrl-S

Saves the current project's rotation file being edited (in the current WEPS project directory). The "saved" filename will become the selected management file in the main WEPS interface screen upon exit of MCREW.

• Save As Ctrl-A

Displays a "Save File" dialog box from which the user can specify the desired filename to save the rotation file for the current project (the default location is in the current WEPS project directory). The "saved" filename will become the selected management file in the main WEPS interface screen upon exit of MCREW.

• Save As Template Ctrl-L

Displays a "Save File" dialog box from which the user can specify the desired filename to save a copy of the currently edited rotation file into the "Management Templates" directory. The original file is still the current file being edited within MCREW.

Print Ctrl-P

Prints MCREW Table View. Clicking this item displays a print dialog box through which the MCREW table view can be printed (Ctrl-P).

• Ex Ctrl-E

Exits MCREW. If MCREW finds that the rotation file has been modified and not saved, it will display a popup message and ask the user if they want to save it before leaving.

Edit

Edit Configure	<u>T</u> ools
Cut Row(s)	Ctrl-X
Copy Row(s)	Ctrl-C
Paste Row(s)	Ctrl-V
Delete Row(s)	Ctrl-D
Sort by Date	Ctrl-R
Insert Row	Ctrl-I
Cycle Forward	Ctrl-F
Cycle <u>B</u> ackward	Ctrl-B

A WEPS 1.0 rotation file is simply a date-ordered list of management operations. MCREW provides basic editing functionality to insert, delete, modify, and change dates for those operations. In WEPS, each operation is defined by a list of physical processes, such as residue burial, soil inversion, flattening standing residue, creation of ridges, planting a crop, etc., which are described to the model via one or more parameter values.

In it's most basic form then, one can "see" a WEPS management rotation file within MCREW via the table view.

The primary editing functions available are accessible via the 'Edit' menu option. The table view editing functions are:

• Cut Row(s) Ctrl-X

Remove the currently selected operation row(s) from the rotation and store them in a temporary buffer for possible pasting back into the rotation later.

• Copy Row(s) Ctrl-C

Copy the selected operation row(s) from the rotation and store in a temporary buffer for possible future pasting back into the rotation.

• Paste Row(s) Ctrl-V

Paste the previously cut or copied operation row(s) above the selected operation.

• Delete Row(s) Ctrl-D

Delete the selected operation row(s).

The "Cut", "Copy", and "Paste" buttons on the toolbar can also be used for those operations.

Sort by Date Ctrl-R

Sort the operations in ascending order by date. See "Management File Date Adjustment Functions" below.

• Insert Row Ctrl-I

Insert a blank row above the selected row.

• Cycle Forward Ctrl-F

Selecting this option causes the last year in the rotation to become the first year in the rotation while the other rotation years are incremented by one year. See "Management File Date Adjustment Functions" below.

• Cycle Backward Ctrl-B

Selecting this option causes the first year in the rotation to become the last year in the rotation while the other rotation years are decremented by one year. See "Management File Date Adjustment Functions" below.

Configure



The "Calibration Toggle" function is the only option listed that is currently implemented in this menu. See "Yield Calibration Functions" below.

• Configuration

Displays a "calibrate" window. This is not functioning in the current version.

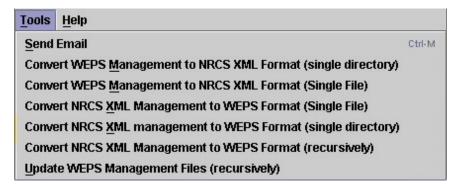
• Column Options

Displays a window that allows the addition or removal of parameter columns from the MCREW screen.

• Calibration Toggle Ctrl-G

Toggle the calibrate yield option on and off.

Tools



The 'Tools' menu item provides access to tools and utilities related to the use of MCREW.

• Send Email Ctrl-M

Provides a method to communicate with WEPS developers via email.

• Convert WEPS Management to NRCS XML Format (single directory)

Converts multiple WEPS management files in a single directory to the NRCS standardized summary management XML file format.

• Convert WEPS Management to NRCS XML Format (Single File)

Converts a single WEPS management file to the NRCS standardized summary management XML file format.

• Convert NRCS XML Management to WEPS Format (Single File)

Converts single NRCS standardized summary management XML format files to the WEPS management file format.

• Convert NRCS XML management to WEPS Format (single directory)

Converts multiple NRCS standardized summary management XML format files to the WEPS management file format.

• Convert NRCS XML management to WEPS Format (recursively)

Converts multiple NRCS standardized summary management XML format files to the WEPS management file format for all the files in the selected directory tree.

• Update WEPS Management Files (recursively)

Updates WEPS management files with the most current crop and operation

database parameters.

Help

The 'Help' menu item displays help options about MCREW and includes:



- <u>H</u>elp Topics Ctrl-H
 Opens a window containing the MCREW online help system.
- <u>About MCREW</u>
 Displays the current version of MCREW.

Button Bar Functions

- This button opens a blank MCREW screen. This has the same function as selecting 'New' under 'File' on the menu bar.
- This button opens an existing MCREW file. This has the same function as selecting 'Open' under 'File' on the menu bar.
- This button saves the rotation file being edited to the current project. This has the same function as selecting 'Save' under 'File' on the menu bar.
- This button cuts a row or rows of the management file and place into the clipboard.

 This has the same function as selecting 'Cut Row(s)' under 'Edit' on the menu bar.
- This button copies a row or rows of the management file and place into the clipboard.

 This has the same function as selecting 'Copy Row(s)' under 'Edit' on the menu bar.
- This button pastes a row or rows of the management file from the clipboard. This has the same function as selecting 'Paste Row(s)' under 'Edit' on the menu bar.



This button sorts the rows of the management operations into date order. This has the same function as selecting 'Sort by Date' under 'Edit' on the menu bar.



This button cycles the rotation year for the management operations forward. This has the same function as selecting 'Cycle Forward' under 'Edit' on the menu bar.



This button cycles the rotation year for the management operations backward. This has the same function as selecting 'Cycle Forward' under 'Edit' on the menu bar.



This button is for popup help. Click on this button, then on any item of the screen for help on that item.



This button toggles the display of extra columns for yield calibration. When this option is on (columns displayed), a red border surrounds the button.



This button saves the currently displayed data and closes MCREW.

Editing Using the Table View

Row and Cell Selection Functions

The mouse is currently the primary method used to "select" either a row and/or an individual table cell. If a particular table cell cannot be directly edited within the cell, this is indicated by a gray background, (e.g., Date, Operation Name or Crop) and the row is selected (indicated by the dark blue background in all cells within the row) along with the individual cell (indicated by the red rectangular border around the cell). See the figure below for an example of a row selection after a left mouse click on the "Cultivator" operation cell.

Date	Operation Name	Сгор	Tillage Dir. (Deg.)
15 Apr, 1	Chisel plow - 2 inch wide straight pts		0.0
20 Apr, 1	Drill - double disk openers (8 inch row spacing)	wheat, spring	0.0
15 Aug, 1	Harvest Small Grain (cutter bar)		
15 May, 2	Cultivator, Field (9 inch shovels)		0.0
15 Jul, 2	Cultivator, Field (9 inch shovels)		0.0
15 Sep, 2	Cultivator, Field (9 inch shovels)		0.0

If the table cell can be directly edited on the table (indicated by a white background in the

table cell), then a left mouse button selection will select the individual cell and immediately allow the user to manually "edit" the value in the cell. For example, left clicking in a "Tillage Dir." cell with a white background activates that cell for editing.

One can select multiple rows at one time by depressing and holding down the left mouse button on the first row to be selected and dragging the mouse cursor over the additional contiguous rows to also be selected. Release the left mouse button on the last row to be selected. All selected rows will be highlighted with a light blue background. The cell the mouse cursor was in when first depressing the left mouse button will be identified by the red rectangular border around it (see the figure below).

Date	Operation Name	Сгор	Tillage Dir. (Deg.)
15 Apr, 1	Chisel plow - 2 inch wide straight pts		0.0
20 Apr, 1	Drill - double disk openers (8 inch row spacing)	wheat, spring	0.0
15 Aug, 1	Harvest Small Grain (cutter bar)		
15 May, 2	Cultivator, Field (9 inch shovels)		0.0
15 Jul, 2	Cultivator, Field (9 inch shovels)		0.0
15 Sep, 2	Cultivator, Field (9 inch shovels)		0.0

The user can append contiguous rows adjacent to a previous, row or multi-row selection, by holding down the "shift" key and clicking the left mouse button on the last desired contiguous row to append to the selection. This is similar to how Microsoft Windows append selection works with the "shift" key depressed.

Similarly, one can append non-contiguous rows (or row) by holding down the "ctrl" key and making an additional multi-row (or single row) selection similar to the original row or multi-row selection (see figure below). As many non-contiguous rows can be selected, as desired, via this method. Again this is similar to how Microsoft Windows non-contiguous selection method works with the "ctrl" key depressed.

Date	Operation Name	Сгор	Tillage Dir. (Deg.)
15 Apr, 1	Chisel plow - 2 inch wide straight pts		0.0
20 Apr, 1	Drill - double disk openers (8 inch row spacing)	wheat, spring	0.0
15 Aug, 1	Harvest Small Grain (cutter bar)		
15 May, 2	Cultivator, Field (9 inch shovels)		0.0
15 Jul, 2	Cultivator, Field (9 inch shovels)		0.0
15 Sep, 2	Cultivator, Field (9 inch shovels)		0.0

Any row or multi-row selection can be de-selected and replaced by simply clicking the left mouse button anywhere within the MCREW table display (with no keyboard keys pressed).

Row Editing Functions

Using the "<u>E</u>dit" menu, the user can cut, copy paste and delete rows. One can also insert a new blank row ("<u>Insert Row</u>") immediately above the currently selected row. Additionally, the user can press the right mouse menu button to display a popup menu that contains row editing functions (see the figure to the left). The "Set Date" and "Adjust Date" options will be described below under "Management File Date Adjustment Functions".

Also, one can insert the contents of another (previously created) management file via the "Insert Management File" option immediately above the currently selected row. The "FileChooser" dialog will popup allowing the user to select the desired management file from which to include all the operations and their associated dates from the selected management file into the current management file being edited.

Management File Date Adjustment Functions

There are several date adjustment functions available in MCREW available in the "**Edit**" menu and the icon toolbar. These operations are:



Sort by Date



Cycle Forward



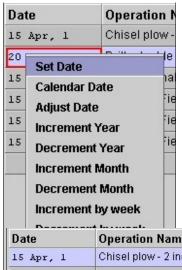
Cycle Backward

The "Sort by Date" function sorts the management operations by ascending date order. Thus, the user can adjust/set the dates of management operations without having to worry about whether they are in the correct sequential order at that time. When the user wants to see the list of operations in the correct date-ordered format, they can simply select the "Sort by Date" function from the toolbar icon or the "Edit" menu.

MCREW will not allow the user to save a WEPS management file without the operations being listed in date order. The user is given the options to automatically sort them, if they are not sorted during a management file save operation, or to go back to the editor and allow the user to correct the problem(s) manually.

The "Cycle Forward" and "Cycle Backward" functions will rotate the "rotation year" of the management operation dates forward or backward in increments of one year. For example, a three year management file rotation "Cycled Forward" would change the operation dates in the first year to the 2nd year, those in the 2nd year to the 3rd year and those in the 3rd year

to the 1st year. Thus, the crops grown and harvested in the first year would now occur in the second year, etc. Likewise, a rotation "Cycled Backward" would shift the rotation the opposite direction, making the 2nd year operations occur in the first year, etc.



Date Column Editing Functions

Limited date editing functions are available by right clicking on a cell in any column. Clicking the right mouse button while the cursor is on a date column cell, causes a date editing popup menu to appear which has additional date editing functions (see figure to the left). These functions allow the user to adjust dates for one row or all operation rows selected (highlighted in blue) simultaneously (single-row date editing operations are made inaccessible and are greyed out if multiple rows are selected).



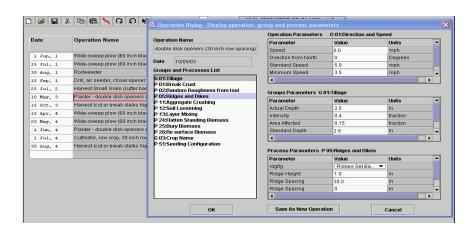
Selecting the "Set Date" option will display a dialog box that allows the user to type in a s p e c i f i c d a t e (day/month/rotation year) for the selected operation row (highlighted in blue). The figure to the left shows an example of "Set Date" popup window.



The "Calendar Date" option displays a popup calendar to aid in adjusting dates. Double left mouse clicking in a date cell, displays the popup calendar as well. This calendar window allows the user to select the desired date. The calendar allows the user to increment (>>) or decrement (<<) the month and year values if desired. Then the day of the operation within that month/year can be selected. The user can either double right mouse click on the day value or click on the "OK" button to accept the specified date (see the figure to the left). The "Calendar Date" function is only applicable when a single operation row is selected.

The "Adjust Date" function is available from this menu, but year, month, week, and day increment and decrement functions are also available. They apply to all dates in the rows that are selected. The user can adjust the operation dates on the selected rows. Selecting the "Adjust Date" option will display a dialog box allowing the user to adjust the operation dates in the selected rows by a specified \pm number of days, months, or years (see figure to the left). Additional menu options are also available to increment or decrement the dates of selected rows by day, week, month and year.

Operation and Crop Drilldown Screens



Both the Operation and Crop cells have "drilldown" function available that allows the user to display a popup screen that makes many of their specific parameter values viewable and/or editable. The specific content of these screens

depend both upon the type of crop or operation and specific XML-format configuration files which describe which parameters are to be made viewable or hidden to the user and if viewable, whether or not they are editable by the user. In addition, for each parameter that is displayed, the prompt information for the parameter is described in these XML-format files.

Jun. 1 Wide-sweep plow (60 inch blade spacing) Wide-sweep plow (60 inch blade spacing) 15 Sep, 1 Drill, air seeder, chisel opener (12 inch row s wheat, winter, h Crop Name corn, grain, 100 25 Jul, 2 Harvest Small Grain (cutter bar) 10 May, 3 Planter - double disk openers (30 inch row sucorn, grain, 100 **Pamrameters** Harvest (cut or break stalks high) 15 Oct, 3 15 Apr. 4 Wide-sweep plow (60 inch blade spacing) Plant population 24280.199999999992 #/acre Wide-sweep plow (60 inch blade spacing) 20 May, 4 ximum number of tillers (stems) per pla 1 Jun, 4 Planter - double disk openers (30 inch row su sunflower Crop growth parameters selection 1 Jul, 4 Cultivator, row crop, 30 inch row spacing (3 ig sture content yield is reported in 30 Aug, 4 Harvest (cut or break stalks high) Crop Type Spring Seeded Grain (seed) fraction of reproduct light extinction coefficient 0.65 Starting depth of growing point 0.05 6.5616 ontimal temperature for plant growth Save As New Crop

Examples of operation and crop

drilldown screens are shown below.

C e 11 - s p e c i f i c drilldown functions are available when a single operation row is selected. The operation drilldown screen is accessible if the selected cell is

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in the operation column (identified by the read rectangular box around it) and a crop drilldown screen is accessible if the selected cell is in the crop column.

Selecting/Replacing Operations and Crops

A new operation can be added to a blank line or a different operation can be selected to replace an existing operation. This is accomplished by double clicking the left mouse button with the mouse cursor in an operation cell. This action will popup the "FileChooser" dialog. It allows the user to select a management operation record from within the dialog window. The user can also access this "FileChooser" dialog from the "Add/Change Operation" menu option via the right mouse menu (described earlier under "Row Editing Functions").

A Crop can be specified for planting (and subsequent harvest) only for operations which contain the "planting/seeding" process. Those that have this process defined will either display the name of the crop to be planted in the "crop" column or display the string "no crop", signifying that no crop is to be planted or it hasn't yet been selected by the user. A crop can be added or an existing crop can be replaced by double clicking the left mouse button with the cursor in a crop cell. This action will popup the "FileChooser" dialog. It allows the user to select a crop record from within the dialog window. The user can also access this "FileChooser" dialog from the "Add/Change Crop" menu option via the right mouse menu (described earlier under "Row Editing Functions").

Choosing a Soil

A soil for a simulation run is selected using the 'Soil' box on the right side of the bottom panel of the WEPS1.0 main screen (Fig. 2.9).



Figure 2.9. Bottom panel of the WEPS main screen with the soil box on the right.

The soil for a simulation run can be selected from the NRCS SSURGO database by clicking the 'Template' folder to the left of the soil name.

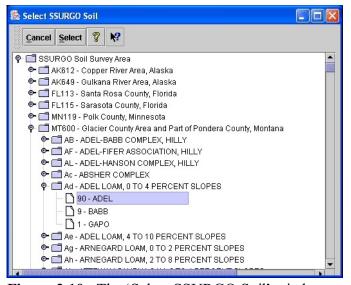


Figure 2.10. The 'Select SSURGO Soil' window.

Clicking on the 'Template' folder opens a window titled 'Select SSURGO Soil' (Fig. 2.10). Navigate through the database tree to find the soil survey area (or county) desired. Navigation is performed by clicking on the 'key' symbol • to open the display to the next level of the tree. To close a level of the tree, click the 'key' symbol ^o to close. The soil files are listed according to the soil map unit symbol, map unit name, surface texture, and local phase. Selecting a soil then lists its components and the percent each component contributes to the map unit. Click a

soil component to highlight it and click the 'Select' button select at the top of the screen (or double click the component with the left mouse button). This action converts the soil from the SSURGO database to a WEPS soil file format (with an 'ifc' extension) and returns the user to the main screen. The loaded soil file name will appear in the soil box window. Clicking the 'Cancel' cancel button on the 'Select SSURGO Soil' window aborts the selection of a new soil. The 'Question' button opens the general help system for WEPS. The 'Context Help' button provides help for a particular item on the toolbar of the 'Select SSURGO Soil' screen. Clicking the 'Context Help' button and then clicking on an item on the toolbar displays a help screen for that item.

Soils that have been previously loaded to projects or modified and saved to another name can be opened by clicking on the '**Project**' folder . This will open a window where the user can select the desired soil or type in the soil file name.

To view the soil data, double click on the button labeled 'Soil', on the left side of the soil box. This will open the WEPS Soil User Interface screen (Fig. 2.<u>11</u>), which allows the user to view, edit (disabled for NRCS), and save the soil information under a new file name under the project.

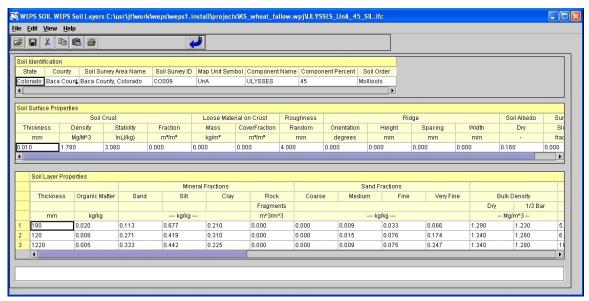


Figure 2.11. WEPS Soil User Interface screen.

Menu Bar Functions

File

This displays a drop down list of various file options.

Open Ctrl-O

Displays an "**Open File**" dialog box from which the user can select a soil (ifc) file from those in the current project.

• Open Local BD Ctrl-L

Open the "Select SSURGO Soil" window (Fig. 2.<u>10</u>) to select a soil from a local database residing on your computer.

• Open Remote DB Ctrl-R

Accesses a remote database on the internet. This function is not currently working.

• Save Ctrl- S

Save the current file.

• Save As Ctrl-A

Save the current soil file to a new name.

• **Print** Ctrl-P

Print the soil file.

• Exit Alt-F4

Exit the soil interface.

Edit

This displays a drop down list of various layer editing functions.

• Cut Layer Ctrl-X

Cut a layer and place it into the clipboard.

• Copy Layer Ctrl-C

Copy a layer and place it into the clipboard.

• Paste Layer Ctrl-V

Paste a layer from the clipboard.

• **Duplicate Layer** Ctrl L

Duplicate the selected layer.

View

This displays options for changing the items displayed in the soil interface. Two options exclusive options are given of which only one is chosen. Click to display 'All fields' required by WEPS on soil interface or click 'Selected fields' to display only the minimum input parameters required for WEPS. The minimum parameter set displayed when 'Selected fields' box is checked is used to estimate the parameters required by WEPS and displayed when 'All fields' box is checked.

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Help

This displays

• **On-Line Help** Ctrl-F1

Button Bar

Making a WEPS Run

WEPS Projects

A "WEPS project" is a directory that can be thought of as a working area where WEPS simulation runs are created and stored along with their outputs. A project stores all the parameters for the current simulation run being prepared within the WEPS interface as well as any past WEPS simulation runs. For example, a particular project may represent a directory for an individual farm under which all the simulation runs for each field and management alternatives on that farm are stored. When a project is saved, all of the information contained on the current interface screen is stored in the project directory. Multiple WEPS projects can be created and given various names by the user. These directories can also be managed (i.e., renamed, deleted, or moved) using a file manager such as Windows Explorer (not provided with WEPS). However, one can remove unnecessary WEPS project and WEPS run directories from within the WEPS interface via the pertinent options under the "File" menu.

All WEPS simulation run results are stored in subdirectories within a WEPS project directory. A WEPS run subdirectory is created every time a simulation run is made. A WEPS run subdirectory stores a copy of all input files used to make the simulation run, together with the output files generated from those inputs. Thus, one is able to reproduce the identical WEPS run at a later date (and presumably get the same outputs when using the same version of WEPS 1.0 and the weather generators/databases) because the original input files are still available. The run directories make it relatively easy for one to archive, rename, or remove WEPS runs as alternative erosion planning scenarios are tested for a field or farm. If, for example, a change is made to create a different management alternative, all the information pertaining to this new scenario will be saved to a new subdirectory (WEPS run name) when the simulation is made.

Project Operations

Clicking the 'Project' menu item displays a list of various operations pertaining to WEPS projects.

The 'New' menu item allows the user to create a new project from scratch. Clicking on this menu item causes WEPS to check for any unsaved changes to the displayed parameters. If there are unsaved changes, the user is asked if they want to 'Save current project?'. If the user clicks 'Yes', the current parameters are saved to the old (current) project. A file chooser then appears that allows the user to specify a name for the new WEPS

project. The current WEPS interface screen is then cleared and the newly created project becomes the current project. If the user clicks 'No', a file chooser opens immediately allowing the user to name the new project to be created and resets the parameters to the system defaults without saving any changes to the previous (current) project. In either case, the user can then proceed to build the new project by entering information on the interface screens. If the user clicks 'Cancel', the process of creating a new project is aborted and the screen returns to the previous project.

The 'Dpen...' menu item opens an existing project. Clicking on this menu item causes WEPS to check for any unsaved changes to the displayed parameters. If there are unsaved changes, the user is asked if they want to 'Save current project?'. If the user clicks 'Yes', the current parameters are saved to the old (current) project. A file chooser then appears that allows the user to specify the name of an existing project to open. The newly opened project becomes the current project. If the user clicks 'No', the old project is closed without saving any changes and a file chooser opens which allows the user to select an existing project to be re-opened. In either case, the user can then proceed to view the project information or modify the project by entering information on the interface screens. If the user clicks 'Cancel', the process of selecting a previous project is aborted and the screen returns to the old project. When leaving the project or WEPS, the user is asked if they want to save the current project.

The ' Save' menu item saves the current WEPS project to the current project name.

'Save As...' allows the user to save a copy of the currently displayed WEPS project to a new name. The copy then becomes the current project.

The default project folder (i.e., directory) under which new projects will be created and existing projects will be opened can be specified under the 'Directories' tab of the 'Configuration' window. Enter the default directory on the line labeled 'Projects Dir'. By default, the last project that was open when WEPS was exited is the current project when WEPS is restarted.



Figure 2.12. The run menu of the main screen.

Make a WEPS Run

Once the desired information is entered through the interface screens, a simulation run can be started. Clicking on the 'Run' menu, then selecting 'Make a WEPS Run' (Fig. 2.12), begins a

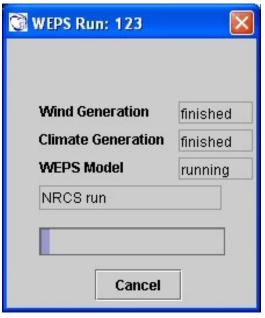


Figure 2.13. WEPS run status window.

WEPS simulation run. Alternatively, one can click the run button | on the button bar to begin a WEPS simulation run. A box will appear asking the user to "Enter a run name". When a run name has been entered, the simulation begins and a window appears which shows the status and progress of the run (Fig. 2.13). Upon completion of a run, a WEPS output summary report will appear for the user to review and print if desired. The summary report is saved in the run directory along with more detailed output reports for later retrieval. The summary and detailed reports for a run can be viewed or created any time by the user. See the section of the WEPS User Manual titled 'Output' for more detailed descriptions of the WEPS output types and how to select them for viewing or printing.

Make a Yield Calibration WEPS Run

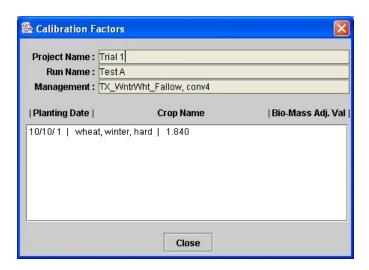
Differences in crop management by producers or local climate variances may result in crop yields, generated by WEPS, that do not reflect the actual yields observed by a producer. WEPS provides a method to "calibrate" yields and associated crop residue biomass from WEPS so that they more accurately reflect those of individual producers or a county as a whole. The following steps describes how to make a yield calibration run.

- a) Within MCREW, press the 'Yield Calibrate' button \(\mathbb{Y} \) to display additional columns related to the crop yield calibration function in WEPS. When the columns are displayed, the 'Yield Calibrate' button is outlined in red \(\mathbb{Y} \).
- b) Within MCREW, select the crop (or crops) that you want to calibrate by setting the 'Yield Calib. flg' column value to '1' for the respective row the crop planting operation is in. Be sure to "tab" or press "enter" after putting that number in the cell to 'register' the flag.
- c) Fill in the desired '**Target Yield**' for the selected crop(s). Note that the units and the moisture content this yield will be reported in are displayed. (Do NOT change the yield units or yield water content values. Doing so will not have the desired affect within the model at

this time. In the future, we expect that this functionality might be made available to the end user). Again, be sure to "tab" or press "enter" after entering the desired target yield value into the cells.

NOTE: More than one crop can be selected for simultaneous yield calibration. However, the algorithms used do not guarantee that a solution will be found when multiple crops are specified for calibration. In practice though, we have found it to work well in most situations.

- d) Save the rotation management file in MCREW. Currently, this can be done by: i) pressing the ' \underline{S} ave' icon $\boxed{\blacksquare}$, ii) via the ' \underline{F} ile > \underline{S} ave' menu option, or iii) using the ' \underline{C} trl- \underline{S} ' keyboard shortcut.
- e) Exit MCREW. This can be done either by: i) clicking on the "close" button \boxtimes in the top right corner of the MCREW window frame or ii) via the '<u>File > Exit</u>' menu option. Note that if one forgets to save the management file before attempting to exit MCREW, the user will be notified and given the opportunity to do so before exiting MCREW.
- f) Click the 'Make a Yield Calibration WEPS Run' via the 'Run' menu option on the main screen (Fig. 2.12). The shortcut 'Ctrl-C' will also work if the main WEPS screen has focus.



g) After the Calibration Run has completed, a popup dialog window will appear that displays the 'Calibration Factors' for each crop selected for calibration (see figure to the left). One can then enter these values back into the management file using MCREW -(remember to press the yield calibration button Y to display the extra crop calibration parameter columns). For each crop that had been "calibrated", enter the new values into the 'Biomass Adi. Factor' column. The biomass

adjustment factor determined for each crop is also written into the 'notes' file for the calibration run.

h) To save these changes into a "newly calibrated" crop record file, one must use the "drilldown" feature in the appropriate crop cell to display the list of crop parameters. The user can then save these parameter values to a new "crop record" file using the 'Save As'

function. Appropriately rename the newly calibrated crop record. Once saved, the user can then select and insert that crop record into any WEPS management file using MCREW.

Restore a WEPS Run

A previously created WEPS run can be restored by clicking on the 'Run' menu and selecting 'Restore a WEPS Run' (Fig. 2.12). This will open a file chooser that allows the user to select a previously created WEPS run. Alternatively, one can click the restore button R, to restore a run. 'Restoring a WEPS Run' actually loads the inputs of the previous WEPS run into the WEPS interface. These inputs can be modified and a new simulation run again with a new WEPS run name. The new run will be saved into a new subdirectory; previous WEPS runs cannot be overwritten. Runs can be removed via the 'Project>Delete Run' menu option . It is recommended that the user remove unwanted runs regularly to prevent these runs from filling the hard disk space.

Viewing Previous Outputs

Output from either the current run or previous runs can be viewed using the 'ViewOutput' menu (Fig 2.12). This menu allows the user to view output for the most recent (current) or previous runs. Clicking on the 'Current Run' menu item displays a list of output reports for the current (last completed WEPS simulation) run. Clicking on the 'Previous Run' menu item displays list of output reports for previous runs. For previous runs, a file chooser opens to allow the user to pick the desired run for which to view the output. See the section of the WEPS User Manual titled 'Output' for more detailed description of WEPS outputs.

Errors

If an error occurs during a WEPS simulation run, an error message will appear. Once the error message is closed, an e-mail window opens that allows the user to report the error to USDA-ARS Wind Erosion Research Unit (Fig. 2.14). The user should enter an e-mail address and a short message. Click the appropriate box at the bottom of the window to attach either the current project (with all associated run directories) or the current run files to your e-mail. Typically, one would only attach the run unless there is a specific reason to attach the project and all its associated run directories. Because of the number of potential files within a project, attaching a project could create a large size attachment. Note, that by default the project is attached to the e-mail message. If you are connected to the Internet, clicking 'Send' will e-mail the message to WERU, along with any attached files, so that your inquiry can be answered. Also note that the user cannot send e-mail from WEPS unless they

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have correctly configured the WEPS e-mail client within the 'Configuration' window.

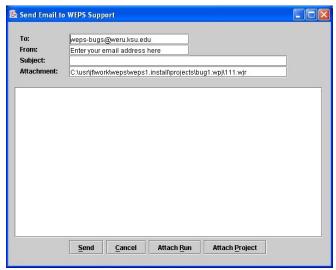


Figure 2.14. E-mail error report window.

WEPS Output

WEPS provides numerous outputs to aid the user in conservation planning. These outputs are accessed through the 'ViewOutput' menu on the main screen. Clicking on this menu displays two choices, 'Current Run' and 'Previous Run'. Clicking on 'Current Run' displays a list of output options for the most recent WEPS run. The 'Previous Run' choice allows the user to view results of previous WEPS runs. A description of the choices under these two submenus follow.

Project Summary

The Project Summary report screen (Fig. 2.15) will automatically display at the conclusion

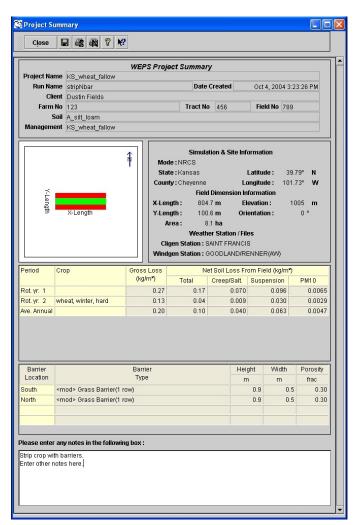


Figure 2.15. The WEPS Project Summary screen.

of a simulation run. If the Project Summary screen has been closed, the user can display the Project Summary screen for the most recent WEPS run or previously run projects by clicking the 'ViewOutput' menu on the WEPS main screen menu bar.

The Project Summary contains names of the input files as well as other input parameters and basic soil loss information by rotation year and the average annual for the total simulation.

Soil loss output in the Project Summary includes: **Gross Loss** which is the average erosion within the field; **Total** which is the average total net loss from the field; **Creep/Salt** which is the average creep plus saltation net loss from the field; **Suspension** which is the average suspension net loss from the field; and **PM10** which is the average PM10 net loss from the field. If an erosion event occurred

but values generated by the model are too small to be displayed on the output table (i.e., <0.001 kg/m²), then the amount is listed as "trace". If amounts are too large to be accurately displayed then the amount is listed simply as greater than a specified amount (i.e., > 300 kg/m²). In these cases erosion amounts are so large that they are generally unacceptable. If any barriers were present on the field borders, a summary of their properties is also listed. Finally, any notes entered on the main screen for the run are reproduced and they can be edited or added to here if desired and saved via the appropriate button at the top of the form.

A button bar is included at the top of the Project Summary screen which allows the user to close the window close the notes to the summary , print the summary , print the notes , open general help for WEPS , and use the context help .

Crop Summary

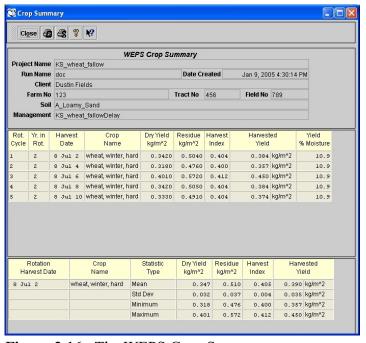


Figure 2.16. The WEPS Crop Summary screen.

The Crop Summary report screen (Fig. 2.<u>16</u>) contains simulation run information including the names of the input files. It also contains a Detailed Report table and a Summary Report table for each crop grown during the simulation run.

The Crop Summary table displays crop yield data for each crop year in the simulation. A table below the Crop Summary Table provides statistical summary parameters for each rotation year. For example, it displays the mean yield for all the simulation years that an individual crop was grown.

A button bar is included at the top of the screen which allows the user to close the window print the crop detail table , print the crop summary table , open general help for WEPS , and use the context help .

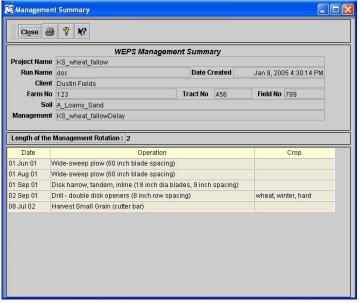


Figure 2.17. The WEPS Management Summary screen.

Management Summary

The Management Summary report screen (Fig. 2.<u>17</u>) displays simulation run information. The Management Summary table displays the management operation date, operation and crop for the run.

A button bar is included at the top of the Management Summary screen which allows the user to close the window close, print the management summary , open general help for WEPS, and use the context help.

Detail Reports

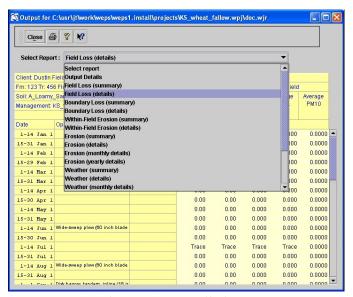


Figure 2.18. The WEPS Detailed Reports screen showing the drop down report list.

The Detailed Reports screen (Fig. 2.18) provides a choice list where the user can select various types of output. The features of the Detailed Reports Screen are described below.

A button bar is included at the top of the Detailed Reports screen which allows the user to close the window close, print any detail report, open general help for WEPS, and use the context help. Below the button bar is a drop down report list labeled 'Select report'. Clicking the down

arrow to the right of 'Select report' displays the list of output available. Click the desired list and it will be displayed in the window below. The following is a description of each report screen.

Output Details

The Output Details report contains all of the erosion, weather, and surface information available by period, by rotation year, and for the entire simulation run.

The columns of the Output Details report have the following information.

Date -This column contains the start and end dates (day/month/rotation year) of the

reporting period.

Operation - This column lists the management operation which occurred on the specified

date (if multiple operations have been specified on the same date, only the last

one listed on that date will be displayed).

Crop -This column lists the crop planted on the specified date.

Wind Erosion

Average Total Gross Soil Loss

- The average erosion (soil loss) within the field, averaged across the field as well as averaged over the number of simulation years in each rotation year (kg/m² or tons/acre). This value is the total amount of soil being removed from the surface of the field. It does not take into consideration the amount of that entrained soil which may be re-deposited downwind within the field due to wind barriers, etc. The "gross" soil loss values are most important when evaluating the "onsite" effects of wind erosion.

Net Soil Loss from Field

The 'Net Soil Loss from Field' columns indicates the "actual" soil loss from the field. Specific areas within the field may experience: 1) a net soil loss, 2) a net soil gain (deposition), 3) no soil movement, or 4) soil movement, but the soil loss is equal to the deposition within the specified area. Under some scenarios, a portion of soil entrained upwind can get deposited within the field borders, due to a reduction in wind speed (and thus it's soil carrying capacity) caused by downwind barriers, changes in surface roughness across

the field, etc. Therefore, the "net" soil loss reported will be less than the "gross" soil loss in these situations. The "net" soil loss values are most important when evaluating "offsite" effects of wind erosion.

Average Total

- The average total net soil loss from the field(kg/m² or tons/acre). This value represents the average amount of soil actually leaving the field boundaries. If there are any downwind barriers, this value will be somewhat less than the 'Average Total Gross Soil Loss' value due to deposition occurring within the field.

Average Creep/Sal.

- Quantity of creep plus saltation size material leaving the field for the period, averaged across the field grid areas, as well as averaged over the number of simulation years in each year of the crop rotation (kg/m² or tons/acre).

Average Susp.

- Quantity of suspension size material leaving the field for the period, averaged across the field grid areas as well as averaged over the number of simulation years in each rotation year (kg/m² or tons/acre).

Average PM10

- Quantity of PM10 material leaving the field for the period, averaged across the field grid areas as well as averaged over the number of simulation years in each rotation year (kg/m² or tons/acre).

Mass of Soil Passing Indicated Field Boundary

These columns display the average soil loss across the indicated field boundary, per unit length of field border, for the specified size range of eroding material.

Creep+Saltation

- Average mass of creep plus saltation size material passing each field boundary (kg/m or tons/1000 ft of field border length) in the direction indicated

Suspension

- Average mass of suspension size material passing each field boundary (kg/m or tons/1000 ft of field border length) in the direction indicated |

PM10

- Average mass of PM10 (particulate matter less than 10 microns) size material passing each field boundary (kg/m or tons/1000 ft of field border length) in the direction indicated .

Within Field Wind Erosion Activity

The information in this section is useful in determining how much of the field is actively

eroding and how much is not, which may impact what control measures, if any should be applied and where. This information is also useful in understanding how much of the field is actively eroding and thus may be causing plant or soil damage or how much is subject to burial. Finally, this information is useful in understanding how much of the field is contributing to overall (net) field loss.

Saltation Emission Region

Soil Loss - This column displays the amount of soil loss from that area of the

field that had significant saltation emission (kg/m² or tons/acre).

Field Area - These columns display both the area (acres or hectares) and fraction

of the field area that had saltation emission.

Deposition Region

Soil Deposition - This column displays the amount of soil deposited in that area of the

field where deposition is the primary activity (kg/m² or tons/acre).

Field Area - These columns display both the area (acres or hectares) and fraction

of the field area that had deposition.

High Flux Region

Field Area - These columns display both the area (acres or hectares) and fraction

of the field area which was near transport capacity.

Sheltered Region

Field Area - These columns display both the area (acres or

hectares) and fraction of the field area that had no saltation or suspension material being emitted. Sheltered areas are typically those immediately

downwind of barriers.

Weather Info

Average Total Period Precip - This column contains the total precipitation for the

period averaged over the simulation years in each year

of the crop rotation (mm or inches).

Average Wind Energy >8 m/s - This column contains the average daily wind energy

for the period for winds greater than 8 m/s, averaged

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over the simulation years in each year of the crop rotation (KJ/day).

Average Snow Cover > 20 mm

- This column contains the total average fraction of time that snow cover on the field which is greater than 20 mm in depth (mm or inches).

Average Biomass Surface Conditions on Date

Crop Vegetation (Live)

Canopy Cover

- This column contains the fraction of live crop biomass cover (vertical view) at the period end, averaged over the simulation years for the period listed (fraction).

Effective Standing Silhouette

- Effective standing silhouette is the standing silhouette area index of live plants expressed on a fraction basis. If the plants are planted in the furrow as opposed to the ridge top, the index is adjusted (down) to have less of an effect on the wind. These are values at the period end averaged over the simulation years in each rotation year.

Above Ground Mass

- This column contains the total live crop biomass, above ground, at the period end, averaged over the simulation years for the period listed $(kg/m^2 \text{ or } lbs/acre)$.

Crop Residue (Dead)

Flat Cover

- This column contains the amount of flat residue cover (dead) on the soil surface, expressed as a fraction. These are values at the period end averaged over the simulation years in each rotation year (fraction).

Effective Standing Silhouette

- Effective standing silhouette is the standing silhouette area index of plant residues expressed on a fraction basis. These are values at the period end averaged over the simulation years in each rotation year.

Flat Mass

- This column contains the amount of flat residue mass

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on the soil surface. These are values at the period end averaged over the simulation years in each rotation year (kg/m² or lbs/acre).

Standing Mass

- This column contains the amount of standing residue mass on the soil surface. These are values at the period end averaged over the simulation years in each rotation year (kg/m² or lbs/acre).

*Live and Dead Biomass*Flat Cover

- This column contains the amount of flat surface cover from live vegetation and residue (flat cover) biomass on the soil surface expresses on a fraction basis. These are values at the period end averaged over the simulation years in each rotation year (fraction).

Effective Standing Silhouette

- Effective standing silhouette is the standing silhouette area index of live vegetation and plant residue. If the plants are planted in the furrow as opposed to the ridge top, the index is adjusted (down) to have less of an effect on the wind. These are values at the period end averaged over the simulation years in each rotation year (fraction).

Flat Mass

- This column contains the amount of flat live vegetation (air dried) and plant residue biomass on the soil surface. These are values at the period end averaged over the simulation years in each rotation year (kg/m^2 or lbs/acre).

Standing Mass

- This column contains the amount of standing live vegetation and plant residue biomass. These are values at the period end averaged over the simulation years in each rotation year (kg/m^2 or lbs/acre).

Average Soil Surface Conditions on Date

Oriented Roughness

Ridge Orientation - This column contains orientation of the ridges with zero

degrees (0°) representing north/south ridges.

Ridge Height

- This column contains the height of ridges. This is the value at the period end averaged over the simulation years in each rotation year (mm or inches).

Ridge Spacing

- This column contains the spacing between ridges. This is the value at the period end averaged over the simulation years in each rotation year (mm or inches).

Random Roughness

- This column contains the standard deviation of the soil surface random roughness. This is the value at the period end averaged over the simulation years in each rotation year (mm or inches).

Aggregation

Aggregates > 0.84 mm

- This column lists the fraction of aggregates greater than 0.84 mm. Aggregates > 0.84 mm are generally considered to be non-erodible. This is the value at the period end averaged over the simulation years in each rotation year.

Aggregate Stability

- This column lists aggregate stability which is the log of crushing energy of dry soil aggregates $(\ln(J/kg))$ and is related to abrasion resistance. This is the value at the period end averaged over the simulation years in each rotation year.

Crust Cover

- This column lists the fraction of the soil surface that is crusted. This is the value at the period end averaged over the simulation years in each rotation year.

The **rows** in the Output Details table vary depending on the number of cropping years in the rotation and the number of management operations in each year of the rotation.

Each year of the rotation has output displayed for the two week periods as well as for each management operation date. This output allows the user to view the erosion and other output for each year of the rotation. At the end of each year in the rotation is a row which contains the average annual value for that rotation year.

The last row in the output form contains the average annual values for the complete crop rotation.

The remaining menu list items on the Detail Reports screen follow and are generally a subset of the Output Detail menu option described above.

Field Loss (summary)

The Field Loss summary report displays average soil loss by rotation year and for the entire simulation run. The values displayed include: Average Total Gross Soil Loss which is the average erosion within the field; Net Average Total which is the average total net loss from the field; Net Average Creep/Salt which is the average creep plus saltation net loss from the field; Net Average Suspension which is the average suspension net loss from the field; and Net Average PM10 which is the average PM10 net loss from the field.

Field Loss (details)

The Field Loss detailed report displays average soil loss by period, by rotation year, and for the entire simulation run. The values displayed include: Average Total Gross Soil Loss which is the average erosion within the field; Net Average Total which is the average total net loss from the field; Net Average Creep/Salt which is the average creep plus saltation net loss from the field; Net Average Suspension which is the average suspension net loss from the field; and Net Average PM10 which is the average PM10 net loss from the field.

Boundary Loss (summary)

The Boundary Loss summary report displays the average mass passing each field boundary (kg/m or tons/1000 ft of field border length) in the direction indicated . These parameters are reported for each rotation year and for the simulation run. The columns labeled 'Creep + Saltation' contain the mass per unit boundary length of creep plus saltation size material which passed the field boundary for each direction. The Suspension columns contain the mass per unit boundary length of suspension size material which passed the field boundary for each direction. The PM10 columns contain the mass per unit boundary length of PM10 size material which passed the field boundary for each direction.

Boundary Loss (details)

The Boundary Loss detailed report displays the average (by period, rotation year, and simulation run) mass passing each field boundary (kg/m or tons/1000 ft of field border length) in the direction indicated . These parameters are reported by period, for each rotation year, and for the simulation run. The columns labeled 'Creep + Saltation' contain the mass per unit boundary length of creep plus saltation size material which passed the field boundary for each direction. The Suspension columns contain the mass per unit boundary length of suspension size material which passed the field boundary for each direction. The PM10 columns contain the mass per unit boundary length of PM10 size material which passed the field boundary for each direction.

Within-Field Erosion (summary)

The Within-Field Erosion summary report displays information for various types of erosion activity by rotation year and for the simulation run. These activities include amounts as well as area and fraction of the field which had significant saltation emission and deposition. In addition high flux and sheltered area and fraction of the field are given. The high flux region

is that area which is near transport capacity. A sheltered area is one that had no saltation or suspension material being emitted. Sheltered areas are typically those immediately downwind of barriers. This information is useful in determining how much of the field is actively eroding and how much is not, which may impact what control measures, if any should be applied and where. This information is also useful in understanding how much of the field is actively eroding and thus may be causing plant or soil damage or how much is subject to burial. Finally, this information is useful in understanding how much of the field is contributing to overall (net) field loss.

Within-Field Erosion (details)

The Within-Field Erosion detailed report displays information for various types of erosion activity by period, by rotation year and for the simulation run. These activities include amounts as well as area and fraction of the field which had significant saltation emission and deposition. In addition high flux and sheltered area and fraction of the field are given. The high flux region is that area that is near transport capacity. A sheltered area is one that had no saltation or suspension material being emitted. Sheltered areas are typically those immediately downwind of barriers. This information is useful in determining how much of the field is actively eroding and how much is not, which may impact what control measures, if any should be applied and where. This information is also useful in understanding how much of the field is actively eroding and thus may be causing plant or soil damage or how much is subject to burial. Finally, this information is useful in understanding how much of the field is contributing to overall (net) field loss.

Erosion (summary)

The erosion summary report displays all of the information available on erosion contained in the sections above labeled Field Loss (summary), Boundary Loss (summary), and Within-Field Loss (summary).

Erosion (details)

The erosion detailed report displays all of the information available on erosion contained in the sections above labeled Field Loss (details), Boundary Loss (details), and Within-Field Loss (details).

Erosion (monthly details)

The erosion detailed report displays all of the information available on erosion contained in the sections above labeled Erosion (summary), but includes monthly average values (averaged across rotation years).

Erosion (yearly details)

The erosion detailed report displays all of the information available on erosion contained in the sections above labeled Erosion (summary), but includes individual simulation year values.

Weather (summary)

The weather summary report displays average total precipitation, the average wind energy for winds greater than 8 m/s (erosive winds), and average fraction of time that snow cover on the field which is greater than 20 mm. These parameters are reported for each rotation year and for the simulation run.

Weather (details)

The weather detailed report displays average total precipitation, the average wind energy for winds greater than 8 m/s (erosive winds), and average fraction of time that snow cover on the field which is greater than 20 mm. These parameters are reported by period, for each rotation year and for the simulation run.

Weather (monthly details)

The weather detailed report displays average total precipitation, the average wind energy for winds greater than 8 m/s (erosive winds), and average fraction of time that snow cover on the field which is greater than 20 mm. These parameters are reported for each rotation year, by month and for the simulation run.

Weather (yearly details)

The weather detailed report displays average total precipitation, the average wind energy for winds greater than 8 m/s (erosive winds), and average fraction of time that snow cover on the field which is greater than 20 mm. These parameters are reported for each rotation year, each individual simulation year and for the simulation run.

Crop (details)

The crop report displays average live above ground biomass conditions that existed on the end date for the period reported. The conditions displayed includes canopy cover, effective standing silhouette, and above ground mass. Canopy cover is the fraction of live crop biomass cover from a vertical view. Effective standing silhouette is the standing silhouette area index of live plants. These values are standing silhouette area per area of soil surface expressed as a fraction. If the plants are planted in the furrow as opposed to the ridge top, the index is adjusted (down) to have less of an effect on the wind. Above ground mass is the total above ground biomass.

Residue (details)

The residue report displays average dead above ground biomass conditions that existed on the end date for the period reported. The conditions displayed includes flat cover, effective standing silhouette, flat mass, and standing mass. Flat cover is the fraction of dead crop biomass cover from a vertical view. Effective standing silhouette is the standing silhouette area index of dead plants. These values are standing silhouette area per area of soil surface expressed as a fraction. If the plants are planted in the furrow as opposed to the ridge top, the index is adjusted (down) to have less of an effect on the wind. Flat mass is the above

ground biomass that is lying flat on the soil surface. Standing mass is the above ground biomass that is in a standing or upright position on the soil surface.

Biomass (details)

The biomass report displays average live plus dead above ground biomass conditions that existed on the end date for the period reported. The conditions displayed includes flat cover, effective standing silhouette, flat mass, and standing mass. Flat cover is the fraction of live plus dead crop biomass cover from a vertical view. Effective standing silhouette is the standing silhouette area index of live plus dead plants. These values are standing silhouette area per area of soil surface expressed as a fraction. If the plants are planted in the furrow as opposed to the ridge top, the index is adjusted (down) to have less of an effect on the wind. Flat mass is the above ground biomass that is lying flat on the soil surface. Standing mass is the above ground biomass that is in a standing or upright position on the soil surface.

Soil Surface (details)

The soil surface report displays average soil conditions at the surface that existed on the end date for the period reported. The conditions displayed includes ridge orientation, ridge height, ridge spacing, random roughness, aggregates greater than 0.84 mm, aggregate stability, and crust cover. Ridge orientation is the orientation of the ridges with zero degrees (0°) representing north/south ridges. Random roughness is the standard deviation of the soil surface roughness height. Aggregates greater than 0.84 mm are expressed as a fraction and are those aggregates generally considered to be non-erodible. Aggregate stability is the log of crushing energy of dry soil aggregates (ln(J/kg)).

Surface Conditions (details)

The surface conditions detailed report displays all of the information available on the field surface contained in the sections above labeled Crop, Residue, Biomass, and Soil Surface.

Debugging Reports

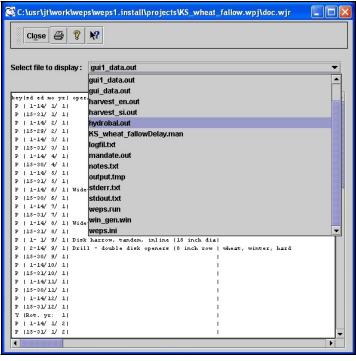


Figure 2.19. The WEPS Debugging Reports screen showing the drop down report list.

The Debugging Reports screen (Fig. 2.19) provides a means of directly accessing all output files generated by the WEPS science model including those that are used by the WEPS user interface to generate reports. A list of selectable output files available on a dropdown list. Clicking the down arrow to the right of 'Select file to display' displays the list of output available. Click the desired list and it will be displayed in the window below. These files are generally for advanced users and model developers. For more information on accessing and interpreting the WEPS science model output files, contact WEPS support.

USING WEPS IN CONSERVATION PLANNING



Interpreting Outputs

Interpreting outputs of WEPS is an important part of controlling wind erosion through conservation planning. By observing how the soil loss is affected by weather and field conditions, the management operations can be adjusted to reduce soil loss. In developing new conservation plans, the user should build or modify several different scenarios and compare outputs to determine the best management to control wind erosion. Because of runtime issues, it is recommended that, for early comparisons, no more than five rotations cycles be used for a simulation. This will allow relative soil loss values for comparisons. Once one or two scenarios are selected, more rotation cycles are recommended for more accurate erosion loss estimates. The number of erosion cycles can be set by selecting "Configuration" then "WEPS Developers Options" menus on the main screen.

The following section outlines the content of the "Output Details" screen.

Date

This column contains the start and end date of the period for which the row information is reported (start day-end day month rotation year). Items in each row represent values from the end of the previous period to the current date. The date column, along with soil loss, will indicate which periods have the greatest wind erosion and are thus in need of changes of management to control wind erosion.

The **rows** in the Output Details screen vary depending on the number of cropping years in the rotation and the number of management operations in each year of the rotation. Each year of the rotation has output displayed for the first two weeks and the 15th to the last day of each month as well as for each management operation date. This output allows the user to view the erosion and other output for each year of the rotation. At the end of each year in the rotation is a row which contains the average annual value for that rotation year. The last row in the output form contains the average annual values for the complete crop rotation.

Operation

This column contains the management operation which occurred on the specified date. It is the management operation or the date of operation which most users will modify to affect field conditions and thus wind erosion.

Crop

This column lists any crops planted on the date shown. Crop is obviously another choice which the land manager may change to control wind erosion.

Wind Erosion

The Wind Erosion columns provide a summary of all the wind erosion soil loss for the simulation run. The numbers in these columns are those that the user will try to affect by

adjusting management dates and operations. If an erosion event occurred but values generated by the model are too small to be displayed on the output table (i.e., $< 0.001 \text{ kg/m}^2$), then the amount is listed as "trace". If amounts are too large to be accurately displayed then the amount is listed simply as greater than a specified amount (i.e., $> 300 \text{ kg/m}^2$). In these cases erosion amounts are so large that they are generally unacceptable.

Average Total Gross Soil Loss

This column contain the gross erosion within the field, averaged across the field as well as averaged over the number of simulation years in each rotation year (kg/m² or tons/acre).

Net Soil Loss from Field

These columns contain net soil loss from the field averaged over the number of simulation years in each rotation year (kg/m² or tons/acre). Some deposition within a field can occur especially when barriers are present downwind. Net soil loss is the amount of gross loss minus deposition. Total is the average total net loss from the field; Creep/Sal is the average creep plus saltation net loss from the field; Susp is the average suspension net loss from the field; and PM10 is the average PM10 net loss from the field.

Mass Passing Indicated Field Boundary

These columns contain the mass per unit length of various sized material which passed the field boundary for each direction (kg/m or tons/1000 ft). This information is useful in determining how much material is leaving the field in each direction. For the creep/saltation size, the material will most likely be deposited on the field boundary such as a stream, fence, ditch, or road. If deposited in a ditch, subsequent rainfall way wash the material in to waterways where it can affect water quality. If deposited on a roadway, the roadway will likely need to be cleared. For suspension and PM10 sizes, the material may travel great distances affecting air quality. The material passing each boundary may indicate that barriers may be needed on the opposite or upwind side of the field to control wind erosion. The direction of soil loss may also indicate a needed change in direction of tillage.

Within Field Wind Erosion Activity

The information in these columns is useful in determining how much of the field is actively eroding and how much is not, which may impact what control measures, if any should be applied and where. This information is also useful in understanding how much of the field is actively eroding and thus may be causing plant or soil damage or how much is subject to burial. Finally, this information is useful in understanding how much of the field is contributing to overall (net) field loss.

Weather

The Weather columns provide a summary of some of the weather information for the simulation run and help the user understand which periods are erosive and why.

Average Total Precip.

This column contains the total precipitation for the period averaged over the simulation years in each year of the crop rotation (mm or inches). This section is useful in determining how precipitation amounts may be affecting biomass production and roughness decay.

Average Wind Energy > 8m/s

This column contains the average daily wind energy for the period for winds greater than 8 m/s, averaged over the simulation years in each year of the crop rotation (KJ/day). This will indicate which periods have the most erosive winds.

Average Snow Cover

If the field is covered with snow, it will be non-erodible.

Average Biomass Surface Conditions on Date

The Average Surface Biomass Conditions on Date columns provide a summary of average surface conditions including crop biomass and soil roughness for the simulation run.

Crop Vegetation (Live)

These columns provide information on the structural configuration of live growing biomass. By observing the canopy cover, the standing silhouette area index, and the above ground mass, the user can determine which periods are not providing sufficient cover to control wind erosion.

Crop Residue (Dead)

These columns provide information on the structural configuration of dead biomass or residue. By observing the flat cover, the standing silhouette area index, the flat mass, and the standing mass, the user can determine which periods are not providing sufficient residue cover to control wind erosion.

Live and Dead Biomass

These columns provide information on the structural configuration of both the live growing biomass and the dead biomass or residue. By observing the flat cover, the standing silhouette area index, the flat mass, and the standing mass, the user can determine which periods are not providing sufficient cover to control wind erosion.

Average Soil Surface Conditions on Date

Roughness

For cropping systems that do not produce sufficient residue for erosion control (e.g., cotton), roughness management is often used to reduce wind friction velocity at the soil surface. This reduces the amount of soil detachment and transport and increases deposition and thus soil loss.

Ridge Orientation

These columns refer to regularly spaced roughness elements caused by tillage implements such as ridges, furrows and dikes. Ridge orientation, width, and height may be adjusted for periods of high soil loss to determine its effect on wind erosion. The user can also follow the roughness decay over time as result of rainfall.

Random Roughness

This column contains the standard deviation of the soil surface random roughness. This is the value at the period end, averaged over the simulation years in each rotation year (inches or mm). Random roughness is primarily the result of aggregate size distribution but is also affected by various types of tillage tools. Random roughness values for typical management operations are listed in Table 3.1. Photographs (Figs. 3.1 - 3.9) can be used as a guide to determine relative random roughness values.

Aggregation

Soil aggregate size and aggregate dry stability affect erosion by wind. Soil aggregates greater than 0.84 mm in diameter are generally considered to be non-erodible. Dry stability is related to abrasion resistance where harder, more stable aggregates result in a lower erodibility of the soil.

Crust Cover

A soil crust will resist abrasion and erosion more than a loose finely divides soil surface. Generally, the more of the surface is covered by a crust, the lower the erosion that occurs. Crust are transient and generally represent a degraded soil quality and therefore should not be relied upon to control erosion by wind. However a high crust cover may explain a lower erosion amount that would normally be expected.

Table 3.1. Random roughness values for typical management operations based on a silt loam soil (Ag. Handbook 537).

Field Operation	Random Roughness (inches)	Field Operation	Random Roughness (inches)
Chisel, sweeps	1.2	Fertilizer applicator, anhydrous knife	0.6
Chisel, straight point	1.5	Harrow, spike	0.4
Chisel, twisted shovels	1.9	Harrow, tine	0.4
Cultivator, field	0.7	Lister	0.8
Cultivator, row	0.7	Manure injector	1.5
Cultivator, ridge till	0.7	Moldboard plow	1.9
Disk, 1-way	1.2	Mulch threader	0.4
Disk, heavy plowing	1.9	Planter, no-till	0.4
Disk, Tandem	0.8	Planter, row	0.4
Drill, double disk	0.4	Rodweeder	0.4
Drill, deep furrow	0.5	Rotary hoe	0.4
Drill, no-till	0.4	Vee ripper	1.2
Drill, no-till into sod	0.3		



Figure 3.1. Random roughness of 0.25 inches (6 mm).



Figure 3.2. Random roughness of 0.40 inches (10 mm).



Figure 3.3. Random roughness of 0.65 inches (17 mm).



Figure 3.4. Random roughness of 0.75 inches (19 mm).



Figure 3.5. Random roughness of 0.85 inches (22 mm).



Figure 3.6. Random roughness of 1.05 inches (27 mm).



Figure 3.7. Random roughness of 1.60 inches (41 mm).



Figure 3.8. Random roughness of 1.70 inches (43 mm).



Figure 3.9. Random roughness of 2.15 inches (55 mm).

Special Field Configurations

Although WEPS 1.0 is designed to simulate rectangular field shapes, special field configurations such as circles or strip cropping can be simulated. By manipulating the field shape to represent a field with the same area and rotating the field along with any barriers many field shapes can be approximated.

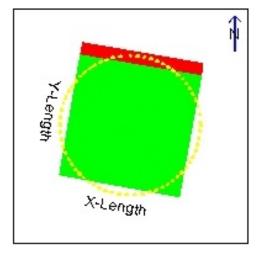


Figure 3.10. Example of using a square field shape to approximate a circle.

<u>Circular Fields.</u> A circular field can be simulated using a square field of equal area. Figure 3.<u>10</u> illustrates how this would be visualized. Note that the yellow dashed circle is shown here to illustrate the circular field and cannot be placed over the field within the WEPS 1.0 interface. For such fields, barriers should be added and the field rotated to best simulate the actual field configuration.

<u>Irregular Field Shapes.</u> Other field shapes can also be simulated with WEPS 1.0. A half circle can be represented with a rectangle as illustrated in Figure 3.<u>11</u>. Figure 3.<u>12</u> illustrates how an irregular field may be visualized for a filed along a stream with filter strips along the North and East sides.

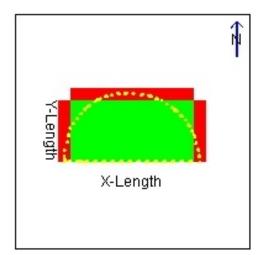


Figure 3.11. Example of using a rectangular field to simulate a half circle.

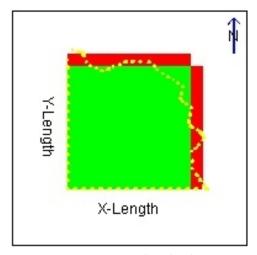


Figure 3.12. Example of using a square field to simulate a field with a stream with buffers along two sides.

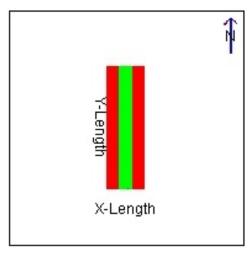


Figure 3.13. Example field layout for simulating strip cropping or grass barriers.

Strip Cropping. Fields managed for wind erosion control by strip cropping in WEPS 1.0 are simulated as linear strips, with each strip of unique management as an individual rectangular field and the erosion losses for each unique strip multiplied by the number of those strips. Ideally, a tract of land where strips are installed will be equally stripped, thus shorting the width of the field along the most erosive winds. The field will be resized down to the strip width that a producer agrees with or to other widths for demonstration purposes. We can change the field size by just typing in the field dimensions. See the section "Describing the Field and Barriers" for more details on adding and modifying field barriers. Figure 3.13 illustrates a field layout for simulating strip cropping or grass barriers.

<u>Tillage Direction.</u> WEPS 1.0 only allows tillage in one direction (e.g., Northwest/Southeast). In other words, multiple tillage directions such as where the operator tills parallel to each border of the field or a circular tillage pattern, cannot be simulated with WEPS 1.0. Observing the effects that tillage direction may have for the particular simulation may illustrate the need to alter tillage directions in the actual field to control wind erosion.

Using Barriers for Erosion Control in WEPS

Using WEPS, we can quickly determine the field edge where the greatest amount of eroded soil is leaving the field. In most cases, a field windbreak would be most effective on the upwind side of this field.

Wind barriers in WEPS include any structure designed to reduce the wind speed on the downwind side of the barrier. Barriers trap moving soil and reduce abrasion of the downwind immobile clods, crusts, and residues along the prevailing wind erosion direction. Barriers include but are not limited to, linear plantings of single or multiple rows of trees, shrubs, or grasses established for wind erosion control, crop protection, and snow management. Snow fences, board walls, bamboo and willow fences, earthen banks, hand-inserted straw rows, and rock walls have also been used as barriers for wind erosion control in limited situations. Barriers also reduce evapotranspiration, shelter livestock, and provide wildlife habitat. One advantage of barriers over most other types of wind erosion control is they are relatively permanent. During drought years, barriers (excepting annual types) may be the only effective and persistent control measure on crop land. Annual barriers are used primarily to provide temporary protection during the most critical wind erosion period and can be removed and replaced every year. Barriers can also be used in sand dune areas to aid the initial stabilization of the areas while grass and trees are being established.

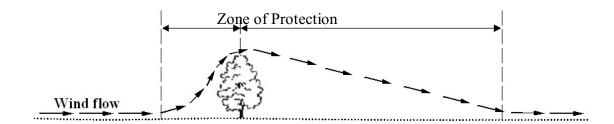


Figure 3.14. Diagram showing wind flow pattern over a barrier.

Barriers primarily alter the effect of the wind force on the soil surface by reducing wind speed on the downwind side of the barrier but also reduce wind speed to a lesser extent upwind of the barrier (Fig 3.14). Research has shown that barriers significantly reduce wind speed downwind, sheltering a portion of the field from erosion and in effect, reducing the field length along the erosive wind direction. However, the protected zone of any barrier diminishes as porosity increases and is reduced significantly when barrier porosity exceed 60 percent. Protection is also reduced as wind velocity increases but the protected area diminishes as the wind direction deviates from the perpendicular to the barrier. Various types of barriers are used for wind erosion control in WEPS 1.0. The WEPS interface provides a method of selecting from a list of barriers to place on the field and editing the barrier

properties. The user can also modify properties in the barrier database that appear in the drop down list. Each of these properties are described below.

The length of a barrier is defined by field length along the border on which the barrier is placed.

Width

The width of a barrier is defined as the distance from one side of the barrier

to the other, in the units of measure displayed on the screen (feet or meters) (Fig. 3.15). For a single row wind barrier, the width is equal to the diameter of the tree, shrub, or grass, or for artificial barriers, the thickness of the material (e.g. slat fence). This is illustrated as "a" in Fig. 3.15. For multiple row barriers, the width is the distance from one side of the barrier to the other as illustrated by "b" in Fig. 3.15.

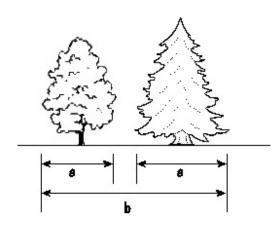


Figure 3.15. Barrier width for single (a) and multiple (b) row barriers.

Height

The height of a barrier is the average height of individual elements (e.g. trees) in the barrier ("a" in Fig. 3.16 for single row barriers). The units of measure for barrier height are displayed on the input screen in feet or meters. For multiple row barriers, use the height of the tallest barrier row ('b" in Fig. 3.16).

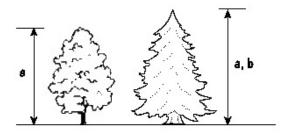


Figure 3.16. Barrier height for single (a) and multiple (b) row barriers.

Area The area of the barrier is calculated from the barrier width and length (i.e.,

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barrier width x field length). This is not an editable item, but is calculated within WEPS 1.0.

Porosity

Barrier porosity is defined as the total optical porosity of all rows in the barrier. It is the open space (i.e., absence of leaves and stems) as viewed looking perpendicular to the barrier, expressed as a percent of the total area (ie., $(1.0 - \text{silhouette area}) \times 100$). WEPS 1.0 does not "grow" living barriers.

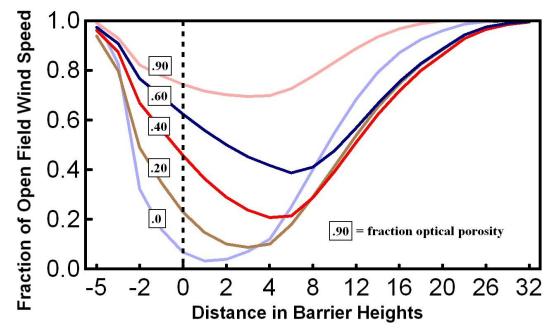


Figure 3.17. Effect of the fraction of optical porosity on near surface wind speed along the wind direction relative to barrier.

They do not increase or decrease porosity with leaf growth and leaf drop (senescence), nor do they increase in size from one year to the next. As such, the porosity of barriers in WEPS does not change with the seasons nor from year to year. Therefore the user should input the porosity of the barrier that is present when the erosion hazard is the greatest. Figure 3.17 illustrates the effect of porosity on the near surface wind speed relative to an open field without a barrier.

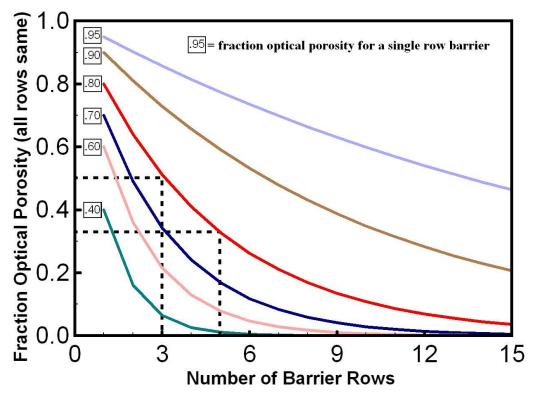


Figure 3.18. Effect of number of barrier rows on optical porosity where all barrier rows are the same.

At times, it is most efficient to estimate optical porosity for a single row, particularly for crop barriers. Then for multiple row barriers, the optical porosity decreases for the entire barrier as illustrated in Figure 3.18. For example, a single row of corn has an optical porosity of 0.80. Three rows of corn have an optical porosity of 0.50 while five rows of corn have an optical porosity of 0.33.

Exercises

WEPS

EVALUATING WIND EROSION PROBLEMS WITH WEPS

This is an example that we will use to evaluate a wind erosion problem in the Stevens Point area of central Wisconsin.

The scenario for the problem is:

- The farm is located near **Stevens Point**, **Wisconsin** in **Portage County**
- The Cligen station is Stevens Point and the Windgen station is Wausau/Alexander
- The Soil Map Unit used in the evaluation is MfB-Mecan-100-LS
- The original two year Cropping system is **Spring Peas** and **Snap Beans (green)**
- The field size is 2640' X2640', 160 acres
- The WEPS evaluation of the cropping system will be run for **20 rotation cycles**

Below (Fig. 3.19) is the two year rotation of Spring Peas and Snap Beans (green) including the dates and field operations. Following evaluation of the erosion rates on the two year rotation, it has been decided to set up a three year rotation to include early potatoes.

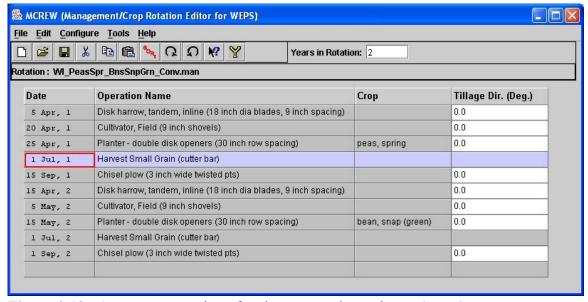


Figure 3.19. A two year rotation of spring peas and snap beans (green).

When we expand the two year rotation to include Early Potatoes, we can add the operations, dates of operation, and the potato crop directly to the two year rotation or we can build a separate template for Early Potatoes and then insert the new template in the rotation. We recommend the option of building a separate template for Early Potatoes and then inserting

it into the existing rotation. The new single year template for Early Potatoes begins when in MCREW by clicking on "File", then click on "New" and this will drop a clean MCREW screen down. With the clean MCREW screen we enter dates and operations as instructed in the section on MCREW. The single year cropping scenario for early Potatoes should be saved as a template. We will save it by clicking on "file" and then "save as a template". The list of management files will drop down and we will go to the window on the bottom of the list called "File name", remove the * and then type in the name single crop scenario we are saving. To finalize we click "Save" on the bottom right of the window. We now have a new single year template and will add it to our two year rotation.

Below (Fig. 3.20) is the three year rotation of Early Potatoes, Spring Peas, and Snap Beans (green) including the dates and field operations. Following evaluation of the erosion rates on the three year rotation, it has been decided to set up a four year rotation to include Sweet Corn.

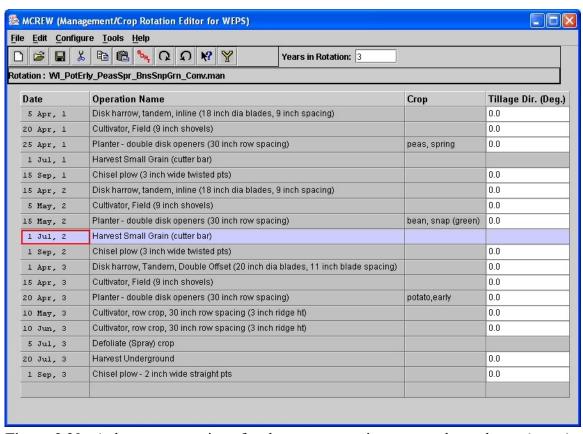


Figure 3.20. A three year rotation of early potatoes, spring peas, and snap beans (green).

When we expand the three year rotation to include Sweet Corn, we again, can add the operations, dates of operation, and the Sweet Corn crop directly to the three year rotation or

we can build a separate template for Sweet Corn and insert the new template into the rotation. We again recommend the option of building a separate template for Sweet Corn and insert it into the existing rotation. Follow the same instruction used above for Early Potatoes to add Sweet Corn.

Below (Fig. 3.21) is the four year rotation of Early Potatoes, Sweet Corn, Spring Peas, and Snap Beans (green) including the dates and field operations. Following evaluation of the erosion rates on the four year rotation, it has been found acceptable.

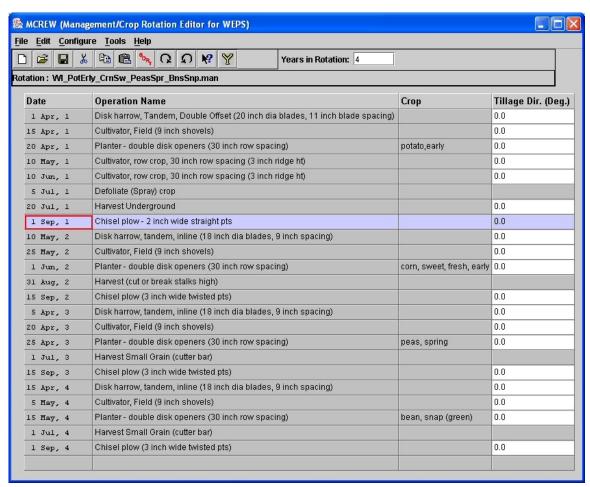


Figure 3.21. A four year rotation of early potatoes, sweet corn, spring peas, and snap beans (green).

EVALUATING WIND EROSION PROBLEMS WITH WEPS

Following are some example problems that we will use to evaluate some wind erosion problems in Marlboro and Charleston Counties, South Carolina.

Situation 1 -2 year rotation developing into a 4 year rotation

The scenario for the problem is:

- The farm is located in Marlboro County, South Carolina
- The Cligen station is McColl and the Windgen station is Florence Regional
- The Soil Map Unit used in the evaluation is: NoA Norfolk LS
- The original 2 year cropping system is Cotton and Watermelons
- The field size is: x axis 3500 ft.; y axis 2000 ft.
- Orientation of field operations and rows is -45 degrees
- Operations are performed parallel to x axis
- The early WEPS evaluations will be run for 5 rotation cycles
- Barriers Woods along the NW and NE field borders (trees w/leaves 4 rows)

Below is a 2 year rotation of **upland cotton** and **watermelons**, including the dates and field operations (Fig. 3.22).

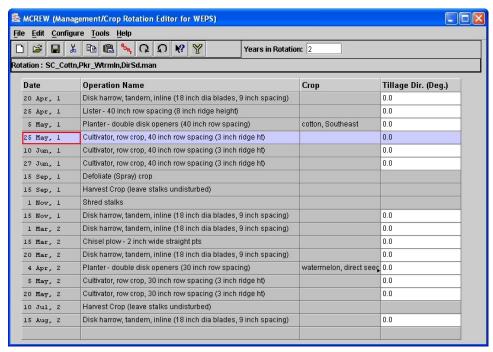


Figure 3.22. A two year rotation of upland cotton and watermelons.

*Cotton, Southeast (700 lbs. lint yield)

- 04/20/01 Disk harrow, tandem, inline (18 inch dia blades, 9 inch spacing)
- 04/25/01 Lister 40 inch row spacing (8 inch ridge height)
- 05/05/01 Planter double disk openers (40 inch row spacing) Cotton, Southeast
- 05/25/01 Cultivator, row crop, 40 inch row spacing (3 inch ridge ht)
- 06/10/01 Cultivator, row crop, 40 inch row spacing (3 inch ridge ht)
- 06/27/01 Cultivator, row crop, 40 inch row spacing (3 inch ridge ht)
- 09/15/01 Defoliate (Spray) crop
- 09/15/01 Harvest crop (leave stalks undisturbed)
- 11/01/01 Shred stalks

* Watermelons, direct seeded

- 11/15/01 Disk harrow, tandem, inline (18 inch dia blades, 9 inch spacing)
- 03/01/02 Disk harrow, tandem, inline (18 inch dia blades, 9 inch spacing)
- 03/15/02 Chisel plow 2 inch wide straight pts.
- 03/20/02 Disk harrow, tandem, inline (18 inch dia blades, 9 inch spacing)
- 04/04/02 Planter double disk openers (30 inch row spacing) Watermelon, direct seeded
- 05/05/02 Cultivator, row crop, 30 inch row spacing (3 inch ridge ht)
- 05/20/02 Cultivator, row crop, 30 inch row spacing (3 inch ridge ht)
- 07/10/02 Harvest crop (leave stalks undisturbed)
- 08/15/02 Disk harrow, tandem, inline (18 inch dia blades, 9 inch spacing)

When we expand the 2 year rotation to include winter wheat /soybeans (double cropped), we can add the operations, dates of operation, and the crops winter wheat /soybeans directly to the 2 year rotation or we can build a separate template for winter wheat /soybeans (double cropped). The new template can then be inserted into the rotation. We recommend the option of building the separate template for winter wheat /soybeans (double cropped) and the template will then be available the next time you are building a rotation that includes that crop.

Below is the 3 year rotation of Cotton, picker; Watermelons; and winter wheat /soybeans (double cropped), including the field operations and the dates they were performed (Fig. 3.23).

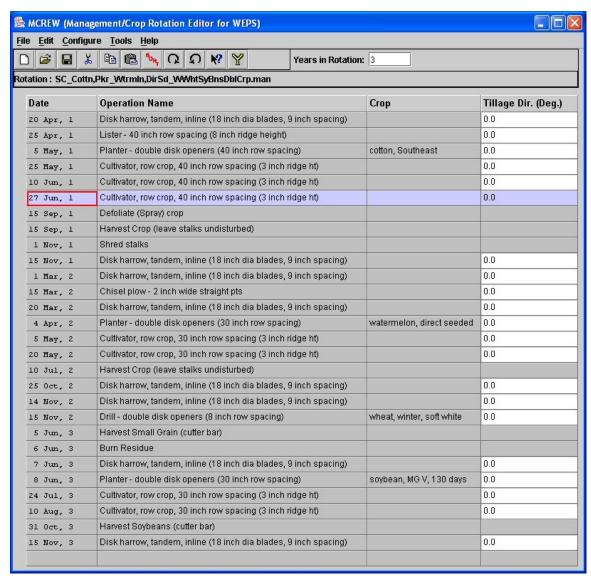


Figure 3.23. A three year rotation of picker cotton, watermelons, and 130 day corn.

*Cotton, Southeast (700 lbs. lint yield)

- 04/20/01 Disk harrow, tandem, inline (18 inch dia blades, 9 inch spacing)
- 04/25/01 Lister 40 inch row spacing (8 inch ridge height)
- 05/05/01 Planter double disk openers (40 inch row spacing) Cotton, Southeast
- 05/25/01 Cultivator, row crop, 40 inch row spacing (3 inch ridge ht)
- 06/10/01 Cultivator, row crop, 40 inch row spacing (3 inch ridge ht)
- 06/27/01 Cultivator, row crop, 40 inch row spacing (3 inch ridge ht)
- 09/15/01 Defoliate (Spray) crop
- 09/15/01 Harvest crop (leave stalks undisturbed)
- 11/01/01 Shred stalks

* Watermelons, direct seeded

- 11/15/01 Disk harrow, tandem, inline (18 inch dia blades, 9 inch spacing)
- 03/01/02 Disk harrow, tandem, inline (18 inch dia blades, 9 inch spacing)
- 03/15/02 Chisel plow 2 inch wide straight pts.
- 03/20/02 Disk harrow, tandem, inline (18 inch dia blades, 9 inch spacing)
- 04/04/02 Planter double disk openers (30 inch row spacing) Watermelon, direct seeded
- 05/05/02 Cultivator, row crop, 30 inch row spacing (3 inch ridge ht)
- 05/20/02 Cultivator, row crop, 30 inch row spacing (3 inch ridge ht)
- 07/10/02 Harvest crop (leave stalks undisturbed)

*Wheat, winter, soft white

- 10/25/02 Disk harrow, tandem, inline (18 inch dia blades, 9 inch spacing)
- 11/14/02 Disk harrow, tandem, inline (18 inch dia blades, 9 inch spacing)
- 11/15/02 Drill double disk openers (8 inch row spacing) wheat, winter, soft white
- 06/05/03 Harvest Small Grain (cutter bar)
- 06/06/03 Burn residue (approximately 800 lbs of residue/acre left on surface)

*Soybeans

- 06/07/03 Disk harrow, tandem, inline (18 inch dia blades, 9 inch spacing)
- 06/08/03 Plant, double disk openers (30 inch row spacing) soybean, MG V, 130 days
- 07/24/03 Cultivator, row crop, 30 inch row spacing (3 inch ridge ht)
- 08/10/03 Cultivator, row crop, 30 inch row spacing (3 inch ridge ht)
- 10/31/03 Harvest Soybeans (cutter bar)
- 11/20/03 Disk harrow, tandem, inline (18 inch dia blades, 9 inch spacing)

Below is the 4 year rotation of picker cotton, watermelons, wheat-soybeans (double cropped); and corn, 130 day; including the field operations and the dates they were performed (Fig. 3.24).

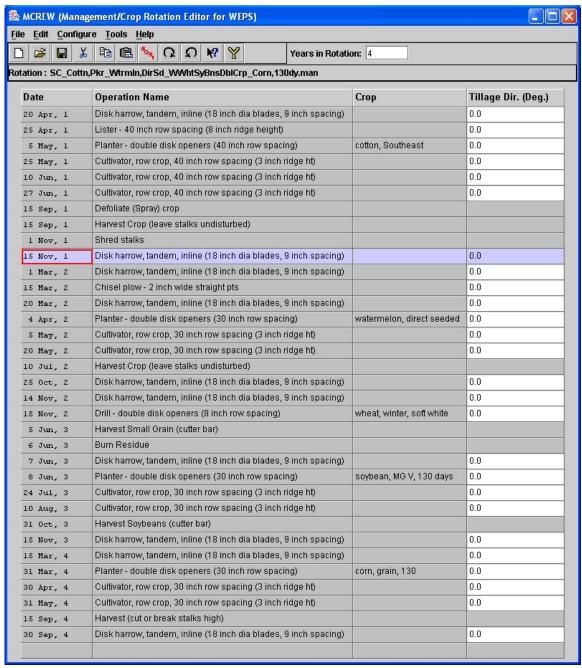


Figure 3.24. A four year rotation of picker cotton, watermelons, wheat-soybeans (double cropped), and corn, 130 day.

*Cotton, Southeast (700 lbs. lint yield)

- 04/20/01 Disk harrow, tandem, inline (18 inch dia blades, 9 inch spacing)
- 04/25/01 Lister 40 inch row spacing (8 inch ridge height)
- 05/05/01 Planter double disk openers (40 inch row spacing) Cotton, Southeast
- 05/25/01 Cultivator, row crop, 40 inch row spacing (3 inch ridge ht)
- 06/10/01 Cultivator, row crop, 40 inch row spacing (3 inch ridge ht)
- 06/27/01 Cultivator, row crop, 40 inch row spacing (3 inch ridge ht)
- 09/15/01 Defoliate (Spray) crop
- 09/15/01 Harvest crop (leave stalks undisturbed)
- 11/01/01 Shred stalks

* Watermelons, direct seeded

- 11/15/01 Disk harrow, tandem, inline (18 inch dia blades, 9 inch spacing)
- 03/01/02 Disk harrow, tandem, inline (18 inch dia blades, 9 inch spacing)
- 03/15/02 Chisel plow 2 inch wide straight pts.
- 03/20/02 Disk harrow, tandem, inline (18 inch dia blades, 9 inch spacing)
- 04/04/02 Planter double disk openers (30 inch row spacing) Watermelon, direct seeded
- 05/05/02 Cultivator, row crop, 30 inch row spacing (3 inch ridge ht)
- 05/20/02 Cultivator, row crop, 30 inch row spacing (3 inch ridge ht)
- 07/10/02 Harvest crop (leave stalks undisturbed)

*Wheat, winter, soft white

- 10/25/02 Disk harrow, tandem, inline (18 inch dia blades, 9 inch spacing)
- 11/14/02 Disk harrow, tandem, inline (18 inch dia blades, 9 inch spacing)
- 11/15/02 Drill double disk openers (8 inch row spacing) wheat, winter, soft white
- 06/05/03 Harvest Small Grain (cutter bar)
- 06/06/03 Burn residue (approximately 800 lbs of residue/acre left on surface)

*Sovbeans

- 06/07/03 Disk harrow, tandem, inline (18 inch dia blades, 9 inch spacing)
- 06/08/03 Plant, double disk openers (30 inch row spacing) soybean, MG V, 130 days
- 07/24/03 Cultivator, row crop, 30 inch row spacing (3 inch ridge ht)
- 08/10/03 Cultivator, row crop, 30 inch row spacing (3 inch ridge ht)
- 10/31/03 Harvest Soybeans (cutter bar)
- 11/20/03 Disk harrow, tandem, inline (18 inch dia blades, 9 inch spacing)

*Corn, 130 day

- 03/15/04 Disk harrow, tandem, inline (18 inch dia blades, 9 inch spacing)
- 04/01/04 Plant, double disk openers (30 inch row spacing) corn, grain, 130
- 05/01/04 Cultivator, row crop, 30 inch row spacing (3 inch ridge ht)

05/21/04 Cultivator, row crop, 30 inch row spacing (3 inch ridge ht) 09/15/04 Harvest (cut or break stalks high) 10/15/04 Disk harrow, tandem, inline (18 inch dia blades, 9 inch spacing)

Situation 2 - Continuous Tomatoes

This is another example problem that we will use to evaluate a wind erosion problem in Charleston County, SC.

The scenario for the problem is:

- The farm is located in **Charleston County**, **SC**
- The Cligen station is Charleston and the Windgen station is Charleston
- The Soil Map Unit used in the evaluation is: NoA Norfolk LS
- The continuous cropping system is **Tomatoes**
- The **field size** is: x axis 2000 ft.; y axis 1500 ft.
- Orientation of field operations and rows is -45 degrees
- Operations are performed parallel to x axis
- The early WEPS evaluations will be run for 5 rotation cycles
- **Barriers** Woods along the NW and NE field borders (trees w/leaves 4 rows)

Below is the 1 year rotation of Tomatoes, including the dates and field operations (Fig. 3.25).

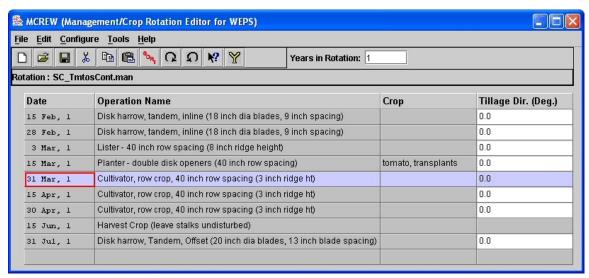


Figure 3.25. A one year rotation of tomatoes.

*Tomatoes

- 02/15/01 Disk harrow, tandem, inline (18 inch dia blades, 9 inch spacing)
- 03/01/01 Disk harrow, tandem, inline (18 inch dia blades, 9 inch spacing)
- 03/03/01 Lister 48 inch row spacing (8 inch ridge height)
- 03/12/01 transplant tomato, transplants
- 04/01/01 Cultivator, row crop, 40 inch row spacing (3 inch ridge ht)

04/15/01 Cultivator, row crop, 40 inch row spacing (3 inch ridge ht)

05/01/01 Cultivator, row crop, 40 inch row spacing (3 inch ridge ht)

06/15/01 Harvest crop (leave stalks undisturbed)

07/25/01 Disk harrow, tandem, inline (18 inch dia blades, 9 inch spacing)

Situation 3 - Continuous Cotton

This is an example problem that we will use to evaluate a wind erosion problem in Marlboro County, SC.

The scenario for the problem is:

- The farm is located in Marlboro County, SC
- The Cligen station is McColl and the Windgen station is Florence
- The Soil Map Unit used in the evaluation is: FaB Faceville LS
- The continuous cropping system is **Cotton**, **picker**
- The **field size** is: x axis 3500 ft.; y axis 2000 ft.
- Orientation of field operations and rows is **-45 degrees**
- Operations are performed parallel to x axis
- The early WEPS evaluations will be run for 5 rotation cycles
- **Barriers** Woods along the NW and NE field borders (trees w/leaves 4 rows)

Below is the 1 year rotation of **Cotton**, **Picker** including the dates and field operations (Fig. $3.\underline{26}$).

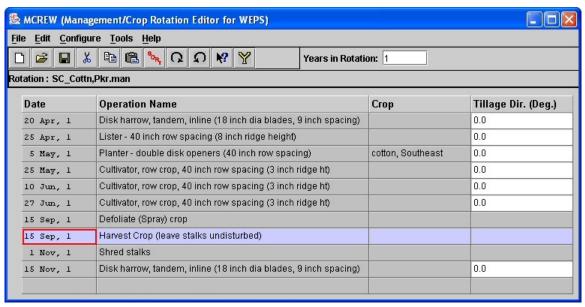


Figure 3.26. A one year rotation of picker cotton.

*Cotton, Southeast (700 lbs. lint yield)

- 04/20/01 Disk harrow, tandem, inline (18 inch dia blades, 9 inch spacing)
- 04/25/01 Lister 40 inch row spacing (8 inch ridge height)
- 05/05/01 Planter double disk openers (40 inch row spacing) Cotton, Southeast
- 05/25/01 Cultivator, row crop, 40 inch row spacing (3 inch ridge ht)
- 06/10/01 Cultivator, row crop, 40 inch row spacing (3 inch ridge ht)
- 06/27/01 Cultivator, row crop, 40 inch row spacing (3 inch ridge ht)
- 09/15/01 Defoliate (Spray) crop
- 09/15/01 Harvest crop (leave stalks undisturbed)
- 11/01/01 Shred stalks
- 11/15/01 Disk harrow, tandem, inline (18 inch dia blades, 9 inch spacing)

EVALUATING WIND EROSION PROBLEMS WITH WEPS

Following are some example problems that we will use to evaluate some wind erosion problems in Haakon County, South Dakota.

Situation 1 -2 year rotation

The scenario for the problem is:

- The farm is located in Haakon County, South Dakota
- The Cligen station is Milesville and the Windgen station is Pierre Municipal
- The Soil Map Unit used in the evaluation is: Craft Cv 85 VFSL
- The original 2 year cropping system is Winter Wheat-Fallow
- The field size is: x axis 2600 ft.; y axis 2600 ft.
- Orientation of field operations and rows is North (0 or 360 degrees)
- Operations are performed parallel to x axis
- The early WEPS evaluations will be run for 5 rotation cycles
- Barriers None

Below is the 2 year rotation of **Winter Wheat** and **Fallow**, including the dates and field operations (Fig. 3.27).

*Winter Wheat (32 bu. yield) – Fallow (Conventional)

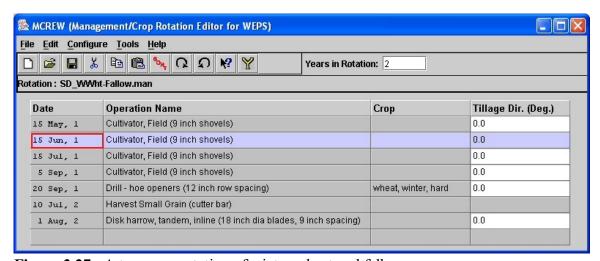


Figure 3.27. A two year rotation of winter wheat and fallow.

When we expand the 2 year rotation to include Forage Sorghum/Sudan Grass Cross (Kane) (Fig. 3.28), we can add the operations, dates of operation, and the Kane crop directly to the

2 year rotation or we can build a separate template for Kane. The new template can then be inserted into the rotation. We recommend the option of building the separate template for Kane and the template will then be available the next time you are building a rotation that includes that crop.

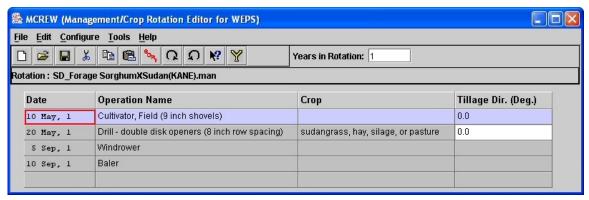


Figure 3.28. A one year rotation of forage sorghum/Sudan grass cross (kane).

Below is the 3 year rotation of Winter Wheat; Fallow; and Kane, including the field operations and the dates they were performed (Fig. 3.29).

*Winter Wheat (32 bu. yield) – Fallow (Conventional) and Kane (~ 6000 lbs.)

e <u>E</u> dit <u>C</u> onfig	ure <u>T</u> ools <u>H</u> elp		
	K 🖺 🖺 🔖 🔾 🗘 🦞 Years in Rotat	tion: 3	
tation: SD_WWht-Kane-Fallow.man			
Date	Operation Name	Сгор	Tillage Dir. (Deg.)
15 May, 1	Cultivator, Field (9 inch shovels)		0.0
15 Jun, 1	Cultivator, Field (9 inch shovels)		0.0
15 Jul, 1	Cultivator, Field (9 inch shovels)		0.0
5 Sep, 1	Cultivator, Field (9 inch shovels) 0.0		
20 Sep, 1	Drill - hoe openers (12 inch row spacing)	wheat, winter, hard	0.0
10 Jul, 2	Harvest Small Grain (cutter bar)		
1 Aug, 2	Disk harrow, tandem, inline (18 inch dia blades, 9 inch spacing)		0.0
10 May, 3	Cultivator, Field (9 inch shovels)		0.0
20 May, 3	Drill - double disk openers (8 inch row spacing) sudangrass, hay, silage, or pasture		0.0
5 Sep, 3	Windrower		
10 Sep, 3	Baler		

Figure 3.29. A three year rotation of winter wheat, fallow, and kane.

EVALUATING WIND EROSION PROBLEMS WITH WEPS

Following are some example management scenarios that we will use to evaluate a wind erosion problem in the Northwest area of Texas.

Situation 1 - Continuos Cotton rotation

The management scenario to be evaluated is:

- The farm is located in Lubbock County, Texas
- The Cligen Station is Lubbock and the Windgen Station is Lubbock
- The Soil Map Unit used in the evaluation is Amarillo 4 100 LFS
- The original Cropping system is Continuos Cotton, stripper
- The **field size** is 2640' X 2640' (160 acres)
- The WEPS evaluation of the cropping system will be run for 5 rotation cycles

Below is the **Continuos Cotton** rotation including the **dates** and **field operations** (Fig. 3.30).

Cotton (Yield of ½ Bale)

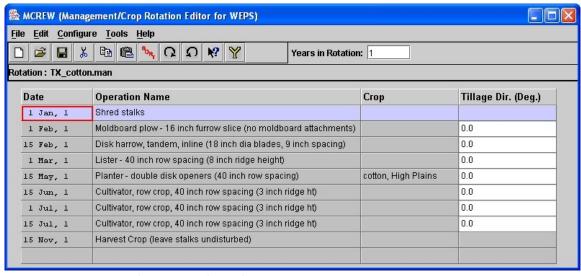


Figure 3.30. A continuos rotation of cotton.

<u>Situation 2</u> – Cotton_Milo rotation

When we expand the 1 year cotton rotation to include Milo, we can add the operations, dates of operations, and the Milo crop directly to the original Cotton rotation or we can build a separate template for Milo and then insert the new template in the rotation. We recommend the option of building a separate template for Milo and then inserting it into the existing Cotton rotation. The new single year template for Milo begins by opening MCREW, clicking on "File", then click on "New" and this will drop a clean MCREW screen down. With the clean MCREW screen we just start entering dates and operations as instructed in the earlier lessons on MCREW. The single year cropping scenario for Milo should be saved as a template. Saving a template begins by clicking on "file" and then "save as a template". The list of dot man folders and files will drop down. Here we can open a folder before saving, or we can go directly to the window on the bottom of the list called "File name", remove the * and then type in the name of the new template we are saving. To finalize we click "Save" on the bottom right. We now have a new single year Milo template and will add it to our existing Cotton scenario.

Below is the **2 year rotation** of **Milo_Cotton**, including the dates and field operations (Fig. 3.31).

	ure <u>T</u> ools <u>H</u> elp			
1 😅 🖫 🐰 🖺 🌊 🦠 🔾 🗘 🏋 🦞 Years in Rotation: 2				
ation: TX_Milo_Cttn,strpr.man				
Date	Operation Name	Сгор	Tillage Dir. (Deg.)	
l Jan, l	Disk harrow, tandem, inline (18 inch dia blades, 9 inch spacing)		0.0	
l Feb, l	Chisel plow - 2 inch wide straight pts	Chisel plow - 2 inch wide straight pts 0.0		
l Mar, l	Disk harrow, tandem, inline (18 inch dia blades, 9 inch spacing)	Disk harrow, tandem, inline (18 inch dia blades, 9 inch spacing) 0.0		
15 Mar, 1	Bedder 0.0			
15 May, 1	Planter - double disk openers (30 inch row spacing) sorghum, grain,		0.0	
15 Jul, 1	Cultivator, row crop, 30 inch row spacing (1 inch ridge ht)		0.0	
15 Oct, 1	Harvest Small Grain (cutter bar)			
1 Jan, 2	Shred stalks			
1 Feb, 2	Moldboard plow - 16 inch furrow slice (no moldboard attachments)		0.0	
15 Feb, 2	Disk harrow, tandem, inline (18 inch dia blades, 9 inch spacing)		0.0	
1 Mar, 2	Bedder		0.0	
15 May, 2	Planter - double disk openers (40 inch row spacing)	cotton, High Plains	0.0	
15 Jun, 2	Cultivator, row crop, 40 inch row spacing (3 inch ridge ht)		0.0	
1 Jul, 2	Cultivator, row crop, 40 inch row spacing (3 inch ridge ht)		0.0	
15 Jul, 2	Cultivator, row crop, 40 inch row spacing (3 inch ridge ht)		0.0	
1 Nov, 2	Harvest Crop (leave stalks undisturbed)			

Figure 3.31. A two year rotation of mile and cotton.

Situation 3 – Cotton Winter Wheat rotation

Below is the 2 year rotation of **Cotton_Winter Wheat** including the dates and field operations (Fig. 3.32). We recommend the option of building the rotation using separate templates of **Cotton** and **Winter Wheat**. However, once you have a template of **Cotton_Winter Wheat**, you can use it directly from your dot man files.

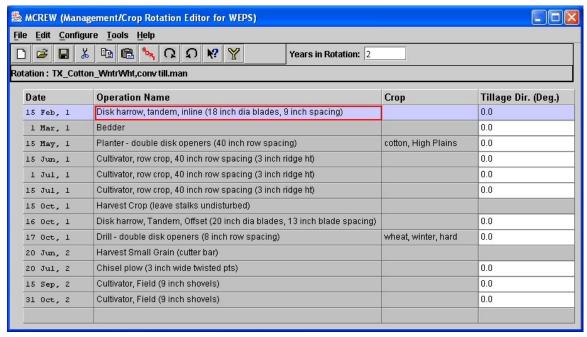


Figure 3.32. A two year rotation of cotton and winter wheat.

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APPENDICES



Appendix 1: Interface Implementation and Science Model

Interface

This section describes the WEPS 1.0 User Interface program implementation and how it interacts with the WEPS science model. The WEPS 'science' model refers to the computer code and executable program that performs the actual calculations of field conditions and erosion processes for a simulation run. A simple flow diagram of the WEPS science model and User Interface is shown in Figure 5.1. A detailed description of how to operate the WEPS 1.0 User Interface is described later in this document (Chapter, 'How to Operate WEPS').

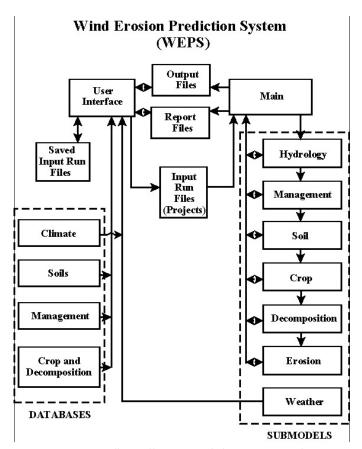


Figure 5.1. A flow diagram of the WEPS science model and User Interface.

A simplified description of the science model is provided later in this chapter. The inputs to the science model reside in a series of ASCII input files. These input files a Windgen file (*.win), a Cligen file (*.cli), an initial field conditions file (*.ifc), a management file (*.man), and a run file (weps.run). The science model can be executed from the command line or through the interface. When WEPS is executed, the science model reads the input files, calls each submodel performing daily time-step simulations, and writes output files. The output is written to one or more ASCII files. Although building input files by hand, executing the model on the command line, and interpreting the output files can be time consuming and confusing, the WEPS 1.0 User Interface simplifies this process.

The WEPS 1.0 User Interface is written in Java. The interface can be thought of as a 'shell' or 'wrapper' around the science model which does not affect the execution of the science

model. Through the interface program, the user can easily enter the information necessary to create and edit the input files. A description of how to enter this information is given later in this document (Chapter, 'How to Operate WEPS'). Once the field, location, soil, and management are described, pressing the 'Run' button performs a series of commands to execute the science model. The interface first calls the Cligen and Windgen weather generators which create the Windgen and Cligen files for the simulation. Then the WEPS science model is called and executed as described above. When the science model is finished, the interface reads and displays the output.

Main Program

The MAIN program is the portion of the science model which controls the initialization and execution of a WEPS simulation run. It calls subroutines that read input data and outputs the general report. In addition, MAIN calls submodels on a daily basis, which update the field conditions. If the maximum wind speed for the day exceeds a set velocity great enough to cause soil movement (i.e., 8 m/s), MAIN then calls the EROSION submodel to simulate erosion processes. The current version of WEPS reads in the climate data produced by the WEATHER submodel; performs daily simulation of the hydrologic and soil conditions, crop growth, and residue decomposition; and accounts for management effects. Finally, the model determines soil erosion by wind for the desired simulation period.

Program Description

The current version of MAIN requires the following files for a WEPS simulation run: a) a simulation run file which describes the field shape and barriers, simulation period, location of other input files, and types of output; b) an initial field conditions file which describes soil conditions at the start of a simulation; d) a tillage/management file which describes the management system; and e) two climate files, one each in the CLIGEN and WINDGEN formats, that provide climate data on a daily basis.

The MAIN program begins by initializing local variables and then calls the subroutine INPUT which reads the simulation run file and the initial field conditions file. The simulation then is executed as a daily loop that controls the counters for the current day. The model can perform any length of simulation on a daily time step. However, WEPS performs a simulation for one rotation cycle to initialize surface conditions before simulations of wind erosion are performed. For each simulation day, the daily weather is read from the CLIGEN and WINDGEN data files. As some of the submodels are executed, summary information may be compiled for output. All submodels except EROSION are called within the subregion loop. Once field conditions are updated, if maximum wind speed for the day exceeds a set minimum (i.e., 8 m/s), the EROSION submodel then is called to determine threshold conditions and compute soil erosion. Finally, the MAIN program calls routines to account for field conditions and soil loss for periods throughout the rotation.

The "WEPS Technical Description" provides a more detailed description of the science behind WEPS and is available from WERU. The current WEPS science model is coded in FORTRAN conforming to the ANSI FORTRAN 77 and Fortran 95 standard. The inputs to the science model reside in a series of ASCII input files. These input files are: a Windgen file (*.win), a Cligen file (*.cli), an initial field conditions file (*.ifc), a management file (*.man), and a run file (weps.run). The science model can be executed from the command line or the interface. When WEPS is executed, the science model reads the input files accesses necessary databases, calls each submodel daily and performs the simulation, and writes output files. The

5.4	APPENDIX 1: SCIENCE - MAIN PROGRAM	WEPS	
output is written to one or more ASCII files.			

Weather Submodel and Databases

WEPS requires wind speed and direction in order to simulate the process of soil erosion by wind. These and other weather variables (precipitation, air temperature, solar radiation) are also needed to drive temporal changes in hydrology, soil erodibility, crop growth, and residue decomposition in WEPS.

Often it is not practical to use measured historical wind data with WEPS, since many wind records have missing data. Also, one may want to simulate wind erosion for a longer period than the length of the measured data record, e.g. for 40 years, which is the length of a typical WEPS simulation run. In addition, the measured data require much more computer disk space than wind summary statistics combined with a stochastic wind generator. Therefore, a stochastic wind generator is often more appropriate for use with WEPS than using the measured data directly.

WINDGEN was developed specifically for use with WEPS. It stochastically generates daily wind direction and hourly wind speed (van Donk et al., 2004). An earlier version of WINDGEN was described by Skidmore and Tatarko (1990). CLIGEN is the weather generator developed for the Water Erosion Prediction Project (WEPP) family of erosion models (Nicks et al., 1987). It is used by WEPS to stochastically generate daily precipitation, maximum and minimum temperature, dew point temperature, and solar radiation. Those interested in CLIGEN and how it simulates these variables should consult the WEPP documentation (Nicks et al., 1995) and the CLIGEN web site (USDA, 2004). Both CLIGEN and WINDGEN are executed under the WEPS user interface.

Statistical distributions of weather variables are needed by stochastic weather generators in order to be able to generate data. There are two steps in the stochastic generation of wind data. First, statistics need to be calculated from a historical record of measured data, describing the distributions of wind direction and speed. Second, the wind data are stochastically generated from these statistics.

Calculation of statistics to be used for stochastic wind generation

A quality controlled hourly wind data set (TD-6421, version 1.1), including 1304 stations in the 48 contiguous states of the USA, was obtained from the National Climatic Data Center (NCDC). Stations with less than 5 years of data were excluded, leaving 971 stations for use with a stochastic generator. Wind direction frequencies wee calculated for each of 16 directions for each month. Wind speeds less than or equal to 0.5 m/s were treated as 'calm'. For the wind speeds that were not calm, the fraction less than or equal to certain wind speeds was calculated for each month-direction combination (12*16=192 combinations per station). The wind speed used were 0.5, 1.5, 2.5, ..., 20.5, 25.5, ..., 45.5 m/s. Rather than using the Weibull model, we chose to use the measured wind speed distributions themselves, without

fitting to any model, but instead using linear interpolation between the measured distribution points. The reasons for this choice are described by van Donk et al. (2004).

Stochastic wind generation

First, one of the 16 cardinal wind directions or calm is selected using a random number generator with the distribution for the current month. The selected direction is applied for an entire day. Next, 24 hourly wind speeds are generated for this day. If calm was selected in the previous step, 24 wind speeds of 0 m/s are generated. Otherwise, if one of 16 directions was selected, 24 wind speeds are generated from the cumulative wind speed distribution. The distribution for the current month and wind direction is selected and a wind speed is generated from the linearly interpolated distribution, using a random number generator.

For more detail on the science behind this submodel please see the WEPS technical documentation.

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Hydrology Submodel

The HYDROLOGY submodel of the Wind Erosion Prediction System (WEPS) uses inputs generated by other WEPS submodels such as WEATHER, CROP, SOIL, MANAGEMENT, and DECOMPOSITION to predict the water content in the various layers of the soil profile and at the soil-atmosphere interface throughout the simulation period. Accurate simulation by the other WEPS submodels requires prediction of the daily changes in soil water profiles. However, estimating soil wetness at the soil-atmosphere interface is emphasized, because it significantly influences the susceptibility of the soil to wind erosion.

The HYDROLOGY submodel of WEPS maintains a continuous, daily, soil water balance using the equation:

$$SWC = SWCI + (PRCP + DIRG) + SNOW - RUNOFF - ETA - DPRC$$
 (5.1)

where SWC is the amount of water on the soil profile in any given day, SWCI is the initial amount of water in the soil profile, PRCP is the amount of daily precipitation, DIRG is the amount of daily irrigation, SNOW is the daily snow melt minus daily snow accumulation, RUNOFF is the amount of daily surface runoff, ETA is the amount of daily actual evapotranspiration, and DPRC is the amount of daily deep percolation.

The amount of daily precipitation (PRCP) is partitioned between rainfall and snowfall on the basis of the average daily air temperature. If the average daily temperature is 0°C or below, the precipitation takes the form of snowfall; otherwise, it takes the form of rainfall.

The snow term (SNOW) can be either positive, equaling the daily snow melt, or negative, equaling the daily snow accumulation. The melted snow is treated as rainfall and added to the precipitation term in Equation 5.1 when accounting for daily runoff and infiltration. On the other hand, the accumulated snow is subtracted from the daily precipitation during the estimation of the daily soil water balance with Equation 5.1.

Simulation of soil-water dynamics on a daily basis by the HYDROLOGY submodel involves three major sequences. First, the submodel partitions the total amount of water available from precipitation, irrigation, and/or snow melt into surface runoff and infiltration. The submodel stores the daily amount of water available for infiltration into the soil profile. Second, the submodel determines the influence of ambient climatic conditions by calculating the potential evapotranspiration. Third, the submodel redistributes soil water in the soil profile on an hourly basis, which provides hourly estimations of water content in the soil profile. The submodel estimates the actual rate of evapotranspiration by adjusting the potential rate on the basis of soil water availability. Deep percolation from the soil profile is estimated to be equal to the conductivity of the lowermost simulation layer, assuming a unit hydraulic gradient.

The HYDROLOGY submodel estimates surface runoff and infiltration for each simulation day that has precipitation and/or irrigation. The submodel estimates the daily amount of water available for infiltration into the soil by subtracting the amount of daily surface runoff from the amount of daily precipitation, snow melt, and/or irrigation. The infiltration water is stored in the uppermost simulation layer, until its water content reaches field capacity. Any excess water then is added to the succeeding lower layer, where it is stored with the same maximum storage restriction. This is repeated until complete water storage is obtained. Any excess water that flows out from the lowest simulation layer becomes a part of deep percolation.

Potential evapotranspiration is calculated using a revised version of Penman's combination method (Van Bavel, 1966). The total daily rate of potential evapotranspiration then is partitioned on the basis of the plant leaf area index into potential soil evaporation and potential plant transpiration. The potential rate of soil evaporation is adjusted to account for the effect of plant residues in the simulation region. Furthermore, the daily potential rates of soil evaporation and plant transpiration are adjusted to actual rates on the basis of water availability in the soil profile.

The HYDROLOGY submodel uses a simplified forward finite-difference technique to redistribute soil water with the one-dimensional Darcy equation for water flow. The time step of the soil water redistribution is 1 hour, which allows for an hourly estimation of soil wetness as needed for WEPS. Knowledge of the relationship between unsaturated hydraulic conductivity and soil water content is required for solving the governing transport equations of water movement through the soil. The submodel uses Campbell's (1974) method to calculate the unsaturated hydraulic conductivity of the soil from the more readily available soil water characteristic curve and saturated hydraulic conductivity data. Because water release curve data of the soil are not always available, the submodel provides alternative options to estimate the hydraulic parameters of the water release curve that are needed as inputs to run the soil water redistribution segment of the submodel.

The HYDROLOGY submodel predicts on an hourly basis soil wetness at the soil-atmosphere interface by using a combination of two techniques. The submodel extrapolates water content to the soil surface from the three uppermost simulation layers. A numerical solution known as Cramer's rule (Miller, 1982) is used to obtain an estimate of the extrapolated water content at the soil surface by solving the three simultaneous equations that describe the relationship between water content and soil depth for the three uppermost simulation layers. The submodel also interpolates the functional relationship between surface-soil wetness and the hourly evaporation ratio.

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Management Submodel

Introduction

WEPS is expected to reflect effects of various management practices upon wind erosion. The diversity of current practices applied to cropland by land managers makes this a daunting task. However, WEPS must adequately simulate typical cultural practices to accurately assess their affects upon wind erosion control. The MANAGEMENT submodel is assigned the task of handling the cultural practices applied by land managers which affect the soil/surface "state" within WEPS.

Purpose

All cultural practices applied by land managers are by definition "human initiated". These human-controlled processes affecting the soil and field surface "state" are initiated by typical management practices such as tillage operations, planting, harvesting, irrigation, etc. Therefore, the purpose of the MANAGEMENT submodel is to model what are considered the *major* human-controllable actions that can affect the "system state" within WEPS, in particular the system state variables defining the temporal soil and surface conditions.

Objectives

The MANAGEMENT submodel objectives are:

- 1. To model the primary human-initiated processes that can affect a site's susceptibility to wind erosion.
- 2. To provide the framework necessary to process a list of specified human-initiated actions, i.e., the cultural practices applied to a field such as a tillage/crop rotation sequence.

Keeping with the WEPS philosophy, The MANAGEMENT submodel simulates processes via a physical basis if possible, incorporates the conservation of mass and energy concepts, and uses a minimum number of parameters with readily available and/or attainable values.

Assumptions and Limitations

Several assumptions and limitations have been imposed on the MANAGEMENT submodel. The reasons vary from simply limiting the scope of the submodel, to inadequate knowledge of specific processes that may have a significant impact on the soil and/or surface. Here is the list of current assumptions and limitations, provided in no particular order, that impact the MANAGEMENT submodel.

 Total soil water content within the current tillage zone is assumed to be unaffected by a tillage operation. The HYDROLOGY submodel is expected to handle changes in surface water content and therefore appropriately represent the usual rapid drying of the surface layer following tillage.

- 2. Tillage depth is assumed to not influence how a tillage operation affects the soil and surface except for determining which soil layers are directly affected by a tillage operation.
- 3. Effects of tillage operations on soil layers below the tillage depth are not considered, i.e., subsoil compaction below the tillage zone due to tillage.
- 4. Effects of a management operation are assumed homogeneous within a subregion. Effects due to tractor tires will not be considered (except where they may knock down a significant proportion of standing residue). Certain zone-related tillage operations, such as row cultivator, will be treated in a manner such that the result will be "averaged" or "equivalent" values which represent the homogeneous region.
- 5. Ridge and dike geometric specifications (oriented roughness) will be provided by the user. If the tillage depth specified is not sufficient to create or destroy them (for a particular tillage operation that does so), the MANAGEMENT submodel will modify the tillage depth accordingly to obtain the desired ridge and/or dike specifications. Tillage operations that do not modify the current ridge and/or dike specifications will not do so (i.e., ridge tillage equipment).
- 6. Soil tillage depths will be adjusted to the nearest soil layer boundary. This will ensure that the most recent tillage operation modifications on the soil "state" are adequately represented.
- 7. Aggregate stability and aggregate density are assumed to be unaffected by tillage operations. This decision is based on limited field data analysis. Future research may provide statistically significant affects that could then be modeled. These properties may still change among soil layers within the tillage zone due to aggregate mixing among layers caused by tillage operations.

Submodel Description

The approach taken within the MANAGEMENT submodel to deal with the variety of land management actions was to:

- 1. Identify the primary physical processes involved.
- 2. Represent individual management operations as a sequence of those primary physical processes.
- 3. Develop a MANAGEMENT file format allowing the input of user-specified sequences of management operations, i.e., a management practices/crop rotation file.

All operations modeled within the MANAGEMENT submodel fall within the following defined management categories as listed in Table 5.1.

Table 5.1. Management operation classes.

Operation Class	Description
Primary tillage	Tillage performed to primarily reduce surface residue, increase short-term infiltration rates, loosen subsoil hardpans, and control weed growth. Usually after-harvest tillage operations fall in this category.
Secondary tillage	Tillage typically performed in preparation for seeding or planting operations. Usually these operations are intended to smooth the soil surface, reduce the average aggregate size, and control weed growth if present.
Cultivation	Tillage specifically designed to eliminate weed growth after crop germination.
Planting/Seeding	Operations required to plant or seed a crop into a field.
Harvesting	Operation to remove biomass from a field. Biomass removed may be grain, root material, or the entire above ground biomass.
Irrigation	The artificial application or addition of water to the soil.
Burning	The removal of surface biomass with fire.

When a management or tillage operation is performed, it is simulated through a group of individual physical processes that represent the total effects of that operation. The basic individual physical processes to be modeled within the MANAGEMENT submodel of WEPS have been grouped according to the target of their actions and outlined in Table 5.2.

Table 5.2. MANAGEMENT submodel processes.

Action	Process	Description
Soil Mass Manipulation	Crush	The application of forces to the soil to modify the soil aggregate structure by breaking down soil aggregates.
	Loosen/ Compact	The process of decreasing soil bulk density and increasing porosity (incorporation of air) or the inverse process of increasing soil bulk density by removing air from the soil.
	Mix	The process of uniting or blending of soil layer properties, including biomass.
	Invert	The reversing of the vertical order of occurrence of soil layers within the current specified tillage zone.
Surface	Ridge/Dike	The process of creating or destroying ridges and/or dikes (oriented surface roughness).
Manipulation	Roughen	The process of modifying the random surface roughness.
	Crust	The process of modifying the soil surface crust characteristics.
	Bury/Lift	The process of moving above ground biomass into the soil or the inverse process of bringing buried biomass to the surface.
Biomass Manipulation	Cut	The process of cutting standing biomass to a prescribed height.
	Drop	The process of moving a portion of the standing biomass to the soil surface.
	Kill	The death of live biomass.
	Remove	The removal of biomass from the system (harvest, grazing, and burning).
Soil Amendments	Plant	Addition of seeds/plants to the soil.
	Irrigate	Addition of water to the soil.

The underlying philosophy behind the MANAGEMENT submodel was to attempt to develop physical law based representations, if possible, for each of the chosen physical processes. These processes are assumed to be independent with respect to each other and are to be simulated sequentially, even though many of them occur simultaneously in the real world. The order they are initiated in the submodel is dependent upon the specific operation.

The list of management operations performed for a given management plan (crop rotation or cyclical management practices) is specified in a MANAGEMENT input file. MANAGEMENT submodel checks on a daily basis for any operations to be performed on that day. If operations are needed, the MANAGEMENT submodel will execute the specified routines required to simulate the effects of those operations as instructed in the MANAGEMENT input file. When the last operation is performed for that particular crop rotation cycle, the same sequence will be repeated for the next year(s) of simulation.

A single MANAGEMENT input file may include multiple management operation lists, one for each subregion being simulated.

Crop Submodel

Introduction

The primary purpose of the WEPS plant growth submodel (CROP) is to obtain realistic estimates of plant growth so that the influence of vegetative cover on soil loss by wind erosion can be properly evaluated. The CROP submodel (Retta and Armbrust, 1995), was adapted from the Erosion Productivity Impact Calculator (EPIC) crop growth model (Williams, et.al, 1990). Additional capabilities and modifications have been developed and incorporated into the CROP submodel to meet the need for predicting effects of a growing crop on wind erosion.

Young seedlings provide some protection from wind erosion. However, not all plant parts are equally effective. Stems of young plants, on a per-unit area basis, are roughly 10 times more effective than leaves in depleting wind energy. Other differences between leaves and stems are that: a) leaves are more sensitive to sandblast damage than are stems; and b) leaf and stem residues decompose at different rates. To properly account for these differences the CROP submodel gives daily estimates of leaf and stem growth in mass and area. At harvest, the 'grain' is removed and the 'straw' may consist of leaves, stems, and 'chaff'. In most cases the leaf and 'chaff' residue is short-lived and only the stem residue may provide protection on a longer-term basis. The CROP submodel gives estimates of the amount of leaf, stem, 'grain', and 'chaff' mass produced on a daily basis.

An important consideration is the effect of plant density on the amount of cover provided by growing seedlings during the early vegetative growth period. Many management practices leave the soil vulnerable to the forces of wind erosion prior to seeding until the growing plants develop sufficient cover. During the period from emergence to the development of adequate cover, the amount of cover is directly proportional to the number of seedlings per unit area. The higher the number of plants per unit area, the greater the cover provided by the growing vegetation. To account for the differences in cover due to initial plant density, the leaf and stem area indexes at emergence (which are used by the EROSION submodel in computations of soil loss) are calculated by multiplying the initial areas per plant by the number of seedlings per unit area. Thus the greater the number of seedlings per unit area at emergence, the greater the protection provided by the young seedlings from wind erosion.

The CROP submodel uses data inputs of plant, weather, hydrology, and management to estimate leaf mass, stem mass, reproductive mass, yield mass, 'chaff' mass, and root mass of 'live' plants (crops) on a daily basis. Other plant characteristics estimated daily are: root mass by soil layer, rooting depth, plant height, and canopy cover.

Phenological development

Phenological development of the crop is based on growing-degree-day (GDD) accumulation.

The crop growth parameters, for each crop, consist of: a) the potential GDDs from planting to physiological maturity; and b) the relative GDDs from planting to emergence, to the start of the reproductive phase, and to the start of leaf senescence. CROP uses the same procedures as EPIC for simulating annual or perennial plants, and winter or summer crops. Annual plants 'grow' from planting to the date when the accumulated GDDs equal the potential GDDs for the crop. For annual winter crops, such as wheat, GDD accumulation (therefore growth) does not occur during the period of dormancy. Perennial crops maintain their root systems throughout the year, although the plant may become dormant after a frost. After the end of dormancy, plants start growing when the average daily air temperature exceeds the base temperature of the plant.

Emergence

Emergence occurs when the GDD accumulation from date of planting equals 6% of the seasonal GDD. The CROP submodel does not account for effects of soil temperature, soil water, soil crusting, soil strength, seeding depth, soil removal or deposition caused by wind erosion, which can influence germination, seedling emergence, survival, and growth.

Biomass Production

Biomass production is determined based upon: a) the amount of shortwave radiation received, which is used to estimate the amount of photosynthetically active radiation (PAR) intercepted by the canopy; and b) the biomass efficiency factor assigned to the crop.

Growth Constraints

Potential growth and yield seldom are achieved, because of stress caused by sub-optimal conditions. The CROP submodel adjusts daily biomass and area growth for water and temperature stresses. Water and temperature stress factors range from 0, where no growth will occur, to 1 for no limitation in normal growth. For any simulation day, the minimum value of the water or temperature stress factor determines the adjustment to daily produced biomass.

References

Retta, A. and D.V. Armbrust.. 1995. WEPS technical documentation: Crop submodel. SWCS WEPP/WEPS Symposium. Ankeny, IA

Williams, J.R., C.A., Jones, and P.T. Dyke. 1990. The EPIC Model. An Erosion/Productivity Impact Calculator: 1. Model Documentation. eds. A.N. Sharply and J.R. Williams. USDA Tech. Bulletin No. 1768.1 235pp.

Residue Decomposition Submodel

This submodel simulates the decrease in crop residue biomass due to microbial activity. The decomposition process is modeled as a first-order reaction with temperature and moisture as driving variables. Decomposition is a function of decomposition days. Under optimum temperature and moisture conditions one decomposition day per day is accumulated. Only a fraction of a decomposition day is accumulated if conditions are less than optimum. Biomass remaining after harvest is partitioned between standing, flat, buried, and root pools. Below ground biomass decomposition is calculated for each soil layer.

Residue from different crops may decompose at different rates. Since residue decomposition can require a long period of time, crop residue biomass from sequential harvests is accounted for in three separate pools. Biomass from the most recently harvested crop will be in pool one, biomass from the penultimate crop in pool two, and there is a third pool for biomass from the oldest crop(s). After harvest, any residue biomass remaining from a previous crop is moved into the older age pools and residue from the just harvested crop is moved into the first residue decomposition pool.

Standing residue losses not only result from microbial activity, but also from physical forces. Physical transfer of crop residue from the standing biomass pool will reduce both the stem population and standing biomass. A daily estimate of the standing stem population is required in order to evaluate the vertical stem area that the wind encounters. This area is quantified by the stem area index, which is calculated from standing stem number, stem height and stem diameter. It affects aerodynamic resistance and, ultimately, wind erosion. Stems start to fall over after a threshold of cumulative decomposition days after harvest has been reached. Stem area index decreases proportionally with standing stem number.

Both standing and flat crop residue provide cover to the soil surface, protecting it against wind erosion. Soil cover from standing residue is estimated from stem number and stem diameter. Soil cover from flat residue is predicted from flat residue mass. Tillage may alter the amount of residue in the different pools.

For more detail on the science behind this submodel please see the WEPS technical documentation.

Soil Submodel

Introduction

All the soil properties that control soil wind erodibility vary with time. Hence, the objective of the soil submodel is to simulate these temporal soil properties on a daily basis in response to various driving processes. On days when wind erosion or management activities occur, the Erosion and Management submodels may also update some of the same temporal variables. The driving processes that change soil temporal properties are mostly weather related, and hence, the sequence of occurrence of individual driving processes is highly variable. Thus, the submodel must be able to update the soil variables given an arbitrary driving process and the soil conditions for the prior day. The purpose of this paper is to provide a brief overview of the major processes that are simulated, and the temporal variables that are updated by the soil submodel. For an in-depth discussion of the equations used in the Soil submodel, see the Soil Submodel Technical Document (Hagen et al., 1995).

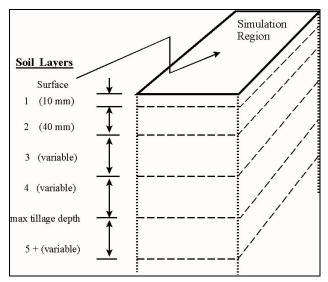


Figure 5.2. Diagram representing the spatial domain of the Soil submodel.

Spatial Regime

In the Soil submodel, the spatial regime is considered to be uniform in the horizontal direction over the simulation region, but non-uniform in the vertical direction (Fig. 5.2). Hence, the vertical direction is divided into layers in each Some of the layer soil profile. boundaries are selected to coincide with the layers determined by the NRCS Soil Survey of each soil. Layers one and two are initially set at 10 and 40 mm (0.39 and 1.57 inches), respectively, to allow simulation of sharp gradients in temporal soil properties near the surface.

Soil Layering Scheme

The hydrology and crop submodels of WEPS depend upon the soil being stratified by layers. Hydrology moves water up and down within the soil based upon the relative wetness of adjacent layers. Crop estimates plant growth based upon several factors, one of the most important being availability of water within the root zone. It is important that WEPS keep track of how much water is available at various soil depths. Hence, WEPS views the soil as a series of layers, each layer possibly having distinct physical characteristics.

WEPS divides the soil into layers based upon National Soil Information System (NASIS) input data. The layering scheme respects the underlying NASIS data. That is, no NASIS layers are combined when creating WEPS layers. Much of the complexity of the layering process is due to the creation of the very thin top layers. The design criteria are:

- 8. Preserve NASIS layering, i.e. a WEPS layer cannot cross a NASIS layer boundary.
- 9. Try to get the first three layers to be 10, 40 and 50 mm.
- 10. Preserve the relative sizes, 1:4:5:5, of the top layers if the absolute size cannot be attained.
- 11.Divide the remaining layers into relatively uniform thicknesses, somewhat thinner at the top and thicker as depth increases.

Processes Simulated and Variables Updated

The processes simulated and the variables updated are summarized in Table 5.3. The effect of the processes on roughness is always to reduce the roughness. In contrast, many of the other variables either increase or decrease in value depending upon the prior-day value, soil intrinsic properties and the driving process. To simulate the dry stability and aggregate size distribution, for a wide range of soils, these variables were first normalized using mean and standard deviation of the variables for each soil series to give a range from 0 to 1 for each variable. The driving processes were then applied to the normalized ranges to determine the change in the normalized variable. Finally, the updated normalized values were converted to the real values of these variables.

Table 5.3. Soil submodel variable and process matrix.

	Surface Processes			Layer Processes		
Soil Temporal Variables	Rain	Sprinkler Irrigation	Snow Melt	Wet/dry	Freeze/thaw	Freeze/dry
Roughness:						
Ridge Height	X	X	X			
Dike Height	X	X	X			
Random	X	X	X			
Crust:						
Depth	X	X	X			
Cover fraction	X	X	X			
Density	X	X	X			
Stability	X	X	X	X	X	X
Loose mass	X	X	X			
Loose cover	X	X	X			
Aggregates:						
Size distribution	X	X	X	X	X	X
Dry stability	X	X	X	X	X	X
Density	X	X	X	X	X	X
Layers:						
Bulk density	X	X	X			

In summary, the Soil submodel outputs updated values on a daily basis for each of the variables listed in Table $5.\underline{3}$ in response to the occurrence of the various driving processes.

References

Hagen, L.J., T.M. Zobeck, E.L. Skidmore, and I. Elminyawi. 1995b. WEPS technical documentation: soil submodel. SWCS WEPP/WEPS Symposium. Ankeny, IA

Erosion Submodel

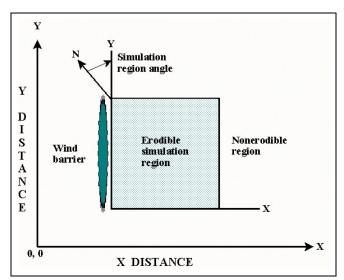


Figure 5.3. Schematic of simulation region geometry. Field orientation, end points of barriers, and opposite corners of the rectangular simulation region are input to the Erosion submodel.

Introduction

The objective of the erosion submodel is to simulate the components of soil loss/deposition over a rectangular field in response to wind speed, wind direction, field orientation, and surface conditions on a sub-hourly basis (Fig. 5.3). In WEPS 1.0 barriers may be placed on any or all field boundaries. When barriers are present, the wind speed is reduced in the sheltered area on both the upwind and downwind sides of the barriers. The submodel determines the threshold friction velocity at which erosion can begin for each surface condition. When wind speeds exceed the threshold, the submodel calculates the loss/deposition over a series of

individual grid cells representing the field. The soil/loss deposition is divided into components of saltation/creep and suspension, because each has different transport modes, as well as off-site impacts. Finally, the field surface is periodically updated to simulate the changes caused by erosion. The purpose of this paper is to provide users with a brief overview of the submodel. For an in-depth description of the equations used in this submodel, see the WEPS Erosion Submodel Technical Description (Hagen, 1995).

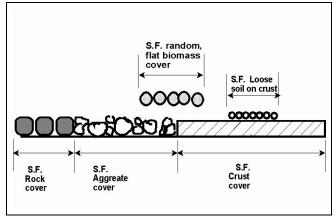


Figure 5.4. Diagram illustrating components of flat surface cover inputs to the Erosion submodel.

Parameters Describing Soil Surface Conditions

Surface roughness is represented by both random roughness and oriented roughness. The parameters used are standard deviation of the surface heights for random roughness and the height, width of ridge tops, and spacing of ridges for oriented roughness.

Surface cover is represented on three levels (Fig. 5.4). In the first level,

surface rock, aggregates and crust comprise 100 percent of the cover. In the second level, the parameter is the fraction of the crusted surface covered with loose, erodible soil. When there is no crust, this parameter is always zero. In the third level, the parameter is the fraction of total surface covered by flat, random biomass.

The aggregate density and size distribution are soil parameters that indicate soil mobility. The dry mechanical stability of the clods/crust are input parameters that indicate their resistance to abrasion from impacts by eroding soil. Surface soil wetness is also input and used to increase the threshold friction velocity at which erosion begins.

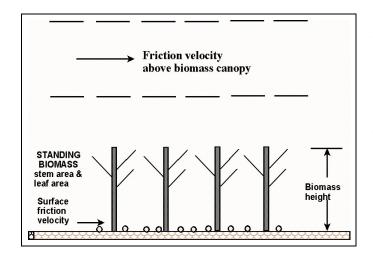


Figure 5.5. Diagram illustrating friction velocity above standing biomass that is reduced by drag of stems and leaves to the surface friction velocity below the standing biomass.

Uniformly distributed, standing biomass is 5 to 10 times more effective in controlling wind erosion than flat biomass, and thus, is treated separately. The wind friction velocity above standing biomass is depleted by the leaves and stems to obtain the friction velocity at the surface that is used to drive erosion (Fig. 5.5). Leaves are represented by a leaf area index and stems by a stem silhouette area index.

Erosion Processes Simulated

Soil transport during wind erosion occurs in three modes: creep-size aggregates, 0.84-2.0 mm (0.033 - 0.079 in.) in diameter roll along the

surface, saltation-size aggregates, 0.10 - 0.84 mm (0.004 - 0.033 in.) in diameter hop over the surface, and suspension-size aggregates, < 0.01 mm (0.004 in.) in diameter move above the surface in the turbulent flow. Obviously, variations in friction velocity, aggregate density and sediment load may change the mass of aggregates moving in a given mode. Saltation and creep are simulated together, because they have a limited transport capacity that depends mainly upon friction velocity and surface roughness. The suspension component is simulated with no upper limit on its transport capacity at the field scale. A portion of the suspension component also is simulated as PM-10, i.e., particulate matter less than 10 micrometers (0.0004 in.) in diameter that is regulated as a health hazard.

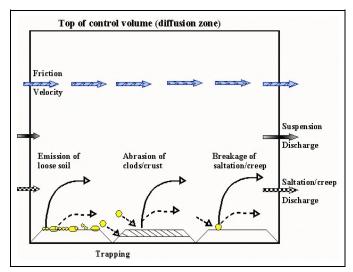


Figure 5.6. Diagram illustrating processes simulated by the Erosion submodel on a bare soil surface in an individual grid cell.

Multiple, physical erosion processes are simulated in the erosion submodel, and these are illustrated for a single grid cell in Fig. 5.6. The two sources of eroding soil are emission of loose soil entrainment of soil abraded from clods and crust. These sources are apportioned between saltation/creep and suspension components based on the source process and soil characteristics. Three processes deplete the amount of moving saltation/creep. These include trapping in surface depressions, interception by plant stems/leaves, and breakage of saltation/creep to suspension-size.

Simulation of surface rearrangement is accomplished by allowing emissions to deplete the loose soil and armor the surface in the upwind field area. In contrast, processes such as abrasion of the protruding aggregates and trapping in depressions dominate in downwind areas and lead to smoothing the surface and a build-up of loose saltation/creep. A build-up of saltation/creep often occurs, because the transport capacity may be satisfied, but abrasion

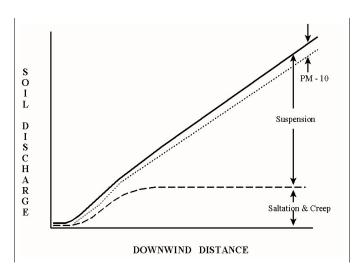


Figure 5.7. Diagram illustrating downwind transport capacity for saltation & creep, but a continuing increase in transported mass of suspension-size soil downwind.

of clods/crust continues to create additional saltation/creep-size soil.

Typical behavior of the downwind soil discharge simulated along a line transect for the saltation/creep and suspension components is illustrated in Fig. 5.7. The suspension component keeps increasing with downwind distance even though saltation/creep reaches transport capacity. This is because the sources for suspension-size soil are usually active over the entire field. These sources include emissions from impacts on loose soil, abrasion from clods/crust, and breakage from impacting saltation/creep-size aggregates. Moreover, the suspension component has a transport capacity many times larger than that of saltation/creep, so on large fields it is the 'freightliner' for moving soil and saltation/creep is merely the 'pickup truck'.

Outputs

The Erosion submodel calculates total, suspension, and PM-10 soil loss/deposition at each grid cell in the field. The grid cell data are summarized in other parts of WEPS and reported to users as averages over the field for selected periods. The submodel also calculates the components of soil discharge crossing each field boundary. These are reported to users based on the size ranges of aggregates as saltation/creep, suspension, and PM-10. These latter outputs are useful for evaluating off-site impacts in any given direction from the eroding field.

References

Hagen, L.J. 1995. Wind Erosion Prediction System (WEPS) Technical Description: Erosion submodel. IN Proc. of the WEPP/WEPS Symposium. Soil and Water Conserv. Soc., Des Moines, IA.

Appendix 2: Databases

Soil Database

The soil data for WEPS is derived from the Soil Survey Geographical (SSURGO) database -developed and maintained by the USDA-NRCS. Below is a list of the data elements which are obtained from SSURGO and a brief description of each.

Descriptive Name (units) - definition - data type

State - The name of the State - character

County - The name of the County - character

Soil Survey Area Name - The name given to the specified geographic area (e.g., soil survey area) - character

Soil Survey ID - A symbol that uniquely identifies a single occurrence of a particular type of area (e.g Lancaster Co., Nebraska is NE109) - character

Map Unit Symbol - The symbol used uniquely identify the soil map unit in the soil survey - character

Component Name - The correlated name of the map unit - character

Component Percent (%) - The percentage of the component of the map unit - integer

Local Phase - A phase criterion used at a local level to help identify soil components - character

Soil Order - The soil taxonomic order of the soil component name - character

Surface Slope (%) - The difference in elevation between two points - float

Soil Albedo (fraction) - The estimated ratio of the incident shortwave (solar) radiation that is reflected by the air dry, less than 2 mm fraction of the bare dry surface soil - float

Surface fragment cover (m3/m3) - The fraction of the surface area covered by rock greater than 2.0 mm.

Soil texture - An expression, based on the USDA system of particle sizes, for the relative proportions of various size groups - character

Soil Loss Tolerance (T factor) (Tons/acre/year) - The maximum amount of erosion at which the quality of a soil as a medium for plant growth can be maintained.

Depth to top of horizon (cm) - The distance from top of the soil to the top of soil horizon - integer

Depth to bottom of horizon (cm) - The distance from top of the soil to the base of soil horizon - integer

Clay (%) - Mineral particles less than 0.002 mm in equivalent diameter as a weight percentage of the total soil - float

Sand (%) - Mineral particles 0.05 to 2.0 mm in equivalent diameter as a weight percentage of the total soil - float

Coarse sand (%) - Mineral particles 0.5 to 1.0 mm in equivalent diameter as a weight percentage of the total soil - float

Medium sand (%) - Mineral particles 0.25 to 0.5 mm in equivalent diameter as a weight percentage of the total soil - float

Fine sand (%) - Mineral particles 0.10 to 0.25 mm in equivalent diameter as a weight percentage of the total soil - float

Very fine sand (%) - Mineral particles 0.05 to 0.10 mm in equivalent diameter as a weight percentage of the total soil - float

Rock fragments by volume (%) - The volume of the horizon occupied by 2 mm or larger fraction - integer

Depth to bedrock (cm) -The observed depth to the top of the bedrock layer.

Depth to restrictive layer (cm) - The distance from the soil surface to the upper boundary of a restrictive layer.

Bulk density 1/3 bar (Mg/m^3) - The oven dried weight of the less than 2.0 mm soil material per unit volume at a tension of 1/3 bar - float

Bulk density oven dry (Mg/m^3) - The oven dried weight of the less than 2.0 mm soil material per unit volume - float

Bulk density initial (Mg/m³) - The oven dried weight of the less than 2.0 mm soil material per unit volume at the beginning of the simulation- float

Water 1/3 bar (cm³/cm³) - The amount of soil water retained at a tension pf 1/3 bar (33 kPa), expressed as a percentage of the less than 2 mm, volumetric basis - float

Water 15 bar (cm³/cm³) - The amount of soil water retained at a tension pf 15 bar (1500 kPa), expressed as a percentage of the less than 2 mm, volumetric basis - float

Saturated hydraulic conductivity ($\mu m/s$) - The amount of water that would move vertically through a unit area of saturated soil in unit time under unit hydraulic gradient - float

Linear extensibility percent (%) - The linear expression of the volume difference of the natural soil fabric at 1/3 bar water content and oven dryness. The volume change is reported as a percent change for the whole soil. - float

Cation exchange capacity (meq/100 g) - The amount of exchangeable cations that a soil can adsorb at pH 7.0 - float. If the soil has a pH < 5.5, the column is blank, otherwise the effective cation exchange capacity will be listed.

Effective Cation exchange capacity (meq/ $100\,g$) - The sum of NH4OAc extractable bases plus KCl extractable aluminum used for soils that have pH < 5.5 - float. If the soil has a pH < 5.5, the effective cation exchange capacity will be listed, if not the column is blank.

Organic matter (%) - The amount by weight of decomposed plant and animal residue expressed as a weight percent of the soil material - float

Calcium carbonate equivalent (%) - The quantity of Carbonate (CO3) in the soil expressed as CaCO3 as a weight percentage of the \leq 2 mm soil - integer

Soil Reaction - pH (unitless) - A numerical expression of the relative acidity or alkalinity of a soil using the 1:1 soil to water method. - float. If the soil is a mineral soil, the pH will be listed, if not, the column is blank.

Soil Reaction - pH (unitless) - A numerical expression of the relative acidity or alkalinity of a soil using the 0.01M calcium chloride method. - float. If the soil is a Histosol, the pH will be listed, if not, the column is blank.

Note that there are two entries for pH and two for CEC. Only one of each of these should be populated depending on the type of soil.

Downloading Soil Data

This section describes how to download soil data from the NRCS Soil Data Mart and how to extract it for use within WEPS. A Microsoft Access database is available for importing the data in the export file. You must have Microsoft Access 97 or later installed on your PC.

Soil data for NRCS and most other users in the US, is currently available for download from the NRCS Soil Data Mart at: http://soildatamart.nrcs.usda.gov/. Soil survey data that is exported from the Soil Data Mart is in what is referred to as "SSURGO" (Soil Survey Geographic) format. To obtain soil data for a Soil Survey Area of interest, go to the Soil Data Mart and click 'Select State' at the top of the Soil Data Mart screen. Select the desired state then click 'Select Survey Area' or 'Select County'. Select the soil survey area, then click 'Download Data'. On the download screen select 'Tabular Data Only', select the version of Microsoft Access on your computer, and enter your e-mail address, then click 'Submit Request'. You will see a message stating "Your request has been logged. At a later time you will receive an e-mail with a link to download the export file. The format of an export file name is: soil_ssasymbol.zip, where ssasymbol is the soil survey symbol of the corresponding soil survey area.

After the export file has been copied to your PC, it must be unzipped using either WinZip or a similar program. For additional information, please see the file named README.txt in the root directory that is created by unzipping the export file. For additional soil survey areas, each zip file should be copied and unzipped into individual directories. When an export file is unzipped, the following directory hierarchy is produced in the directory to which the export file was unzipped:

spatial tabular

The top level directory contains the following files:

soil_metadata_ssasymbol.txt - Federal Geographic Data Committee (FGDC) metadata in plain ASCII format.

soil metadata ssasymbol.xml - the same FGDC metadata in XML format.

readme.txt - a text file containing additional information.

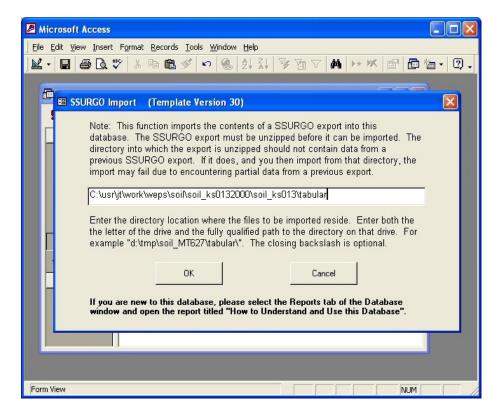
The root directory will also contain a zipped, empty MS Access SSURGO template database, if one was requested as part of the download. The non-extension part of the zipped template database file name varies, but if one was included, it will be the only file in the top level directory with an extension of "zip". This file should be unzipped as well.

The directory "tabular" contains any tabular data that was requested. The directory "spatial" contains any spatial data that was requested. Note that spatial data is not required or recommended (due to file size) for WEPS. It is possible to request tabular data from the Soil Data Mart, without including the corresponding spatial data, and vice versa.

Tabular data is provided as a set of ASCII delimited files. Each file corresponds to a table in the SSURGO 2.1 data model. The tabular data isn't particularly useful until it has been imported into the MS Access SSURGO template database. Current Soil Data Mart downloads include a template database. If a template database was not included in the export file, you can download one from the following URL:

http://soildatamart.nrcs.usda.gov/templates.aspx

Load the template file into MS Access. A 'SSURGO Import' screen will display asking for the full path to the tabular data directory (see figure below). Type the full path of the tabular directory and click 'OK'. A list of database tables will appear and a folder will be created in



the top level directory (with the non-extension part of the template name). At the same time, an MS Access database file (*.mdb) which contains the data required for WEPS, will be created in the template folder. To import more than one soil survey area into a single MS Access database, run the Import macro specifying the full path to the directory the SSURGO data was uncompressed into. Repeat the Import macro for each area desired. When done, save the template database with the imported data to a new name (*.mdb).

Using SSURGO Data With WEPS

Within WEPS, open the "Configuration" window, then click the "Directories" tab. Fill out the full path and SSURGO soil database file name (*.mdb) for "Soil DB" and close the configuration window. Selecting the Soil Template folder at the bottom of the main WEPS screen will display the list of soil survey areas to choose from. Select the desired soil survey area and select the soil map unit and component for the simulation run. If the SSURGO database is not populated with data required by WEPS you will get an error message when selecting that soil. More detailed information on selecting soils, see the "Interface Reference: Choosing a Soil" section of the WEPS User Manual.

Crop Database

Introduction

In the WEPS plant growth submodel biomass is converted from solar radiation and partitioned to root and 'shoot' parts (Fig. 5.8). The shoot mass is partitioned into leaf, stem, and reproductive masses. Finally the reproductive mass is partitioned into grain and chaff parts. Development of the crop in WEPS is a function of the heat unit index, which is the ratio of the cumulated growing degree days at any time to the seasonal growing degree days. The crop reaches maturity when the heat unit index is 1. To perform these and other operations the WEPS plant growth model uses crop parameters. A short description of all the database parameters used in the WEPS plant growth model is below. The parameters consist of a mixture of plant growth, decomposition, and other related information used to simulate plant growth and decomposition in the WEPS model.

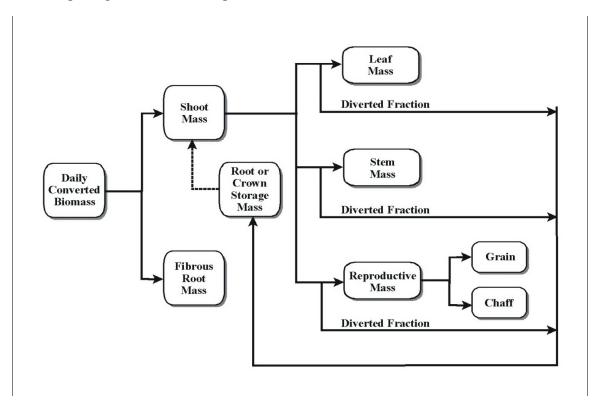


Figure 5.8. Schematic of biomass partitioning in WEPS.

Crop Parameters

Accessing the crop parameters: Many of the crop database parameters can be accessed (i.e., viewed or modified) through the WEPS management/crop rotation editor (MCREW). Double clicking on the folder icon , on the left side of the main screen management box,

will bring up the management/crop rotation editor. This allows the user to modify management scenarios and save them to other file names. The crop parameter window can be accessed by clicking on the folder icon next to a listed crop on the left side of the 'Crop' column of the MCREW window. The crop parameters are grouped in 6 tabs. Many of the parameters are assumed to be crop specific, and therefore should not be changed unless the user establishes that a parameter(s) does not work for their condition. At the top of the crop parameter window is the 'Crop Name' selection list. Clicking on the down arrow displays a list from which to select a crop. This is a list of the common name of the crop, which may be followed by additional descriptors when there are multiple entries for the same crop. For example, 'soybeans, MG 0, 95 days' means that the name of the crop is soybeans belonging to maturity group 0, and takes about 95 days to mature.

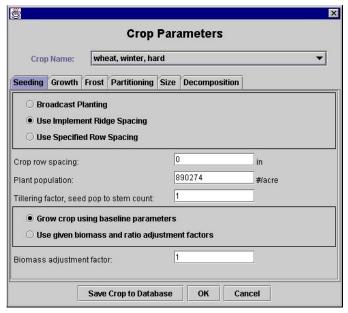


Figure 5.9. Seeding tab window.

Seeding tab (Fig 5.9): This tab has two variables, 'plant population' and 'tillering factor', that are read from the crop database. Plant population is the number of plants or seedlings per unit area. The model assumes 100% germination The tillering factor is the number of tillers per plant. Normally the model is run with the 'Biomass adjustment factor' set to 1.0. However, the model can be run by entering the desired biomass adjustment factor. This choice can be made by clicking on the 'use given biomass and ratio adjustment factors' circle and entering the desired biomass adjustment factor. It is recommended that the use of a

biomass adjustment factor be limited to cases when it can be demonstrated that biomass production was influenced by processes other than those simulated in the model. The default plant population (seeding rate) can be changed to suit the conditions being simulated. As mentioned above plant population density will have an impact on amount of vegetative cover, and therefore erosion rates, during the early part of the growing period. It can also have an impact on 'yield'.

Growth tab (Fig. 5.10): This tab displays ten parameters from the crop database. First the user must select the mode of calculation; whether to use the 'days to maturity' (DTM) mode, or the 'seasonal growing degree days (GDD_s)'. This is done by clicking the appropriate circle

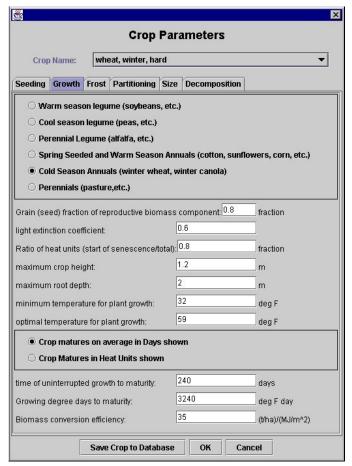


Figure 5.10. Growth tab window.

labeled 'Crop matures on average in Days shown' or 'Crop Matures in Heat Units shown'. GDD is the total growing degree days from planting to physiological maturity. In the GDD_s mode the user can either use the default GDDs or supply another value. In the DTM mode the model computes GDD. internally. A brief description of DTM follows. For annual crops DTM is the number of days from planting to physiological maturity. For perennial crops (e.g. alfalfa), DTM is the number of days from start of spring growth physiological maturity of seed. For perennials, the date of spring planting (or start of spring growth) is not a data entry, but calculated internally in the Crop submodel. For root and vegetable crops, DTM is the number of days from the planting/transplanting date market 'maturity'. Similarly, for tropical fruit crops (e.g. pineapple) DTM is the number of days from

planting to market maturity of fruit. For sugarcane, DTM is the number of days from planting to the time when the cane is ready for cutting. For cover crops DTM is the time from planting at the normal planting time to physiological maturity. If a user feels that the default value of DTM is either too long or too short then the user should replace it to more correctly represent the cultivar or variety being simulated. Since DTM is used in internal computations of GDD_s it determines the length of the growing season. If the user chose the GDD_s mode then the user must ensure that the default GDD_s applies to the variety being simulated. In most cases it is recommended that the DTM method should be used, most users may be more familiar with the number of days a crop may take to mature than with how many growing-degree-days a crop takes to mature. However, the GDD_s method should be used for cover crops that are planted out of season. It is recommended that most of the remaining parameters in this tab should not be changed without proper evaluation.

A brief definition of the parameters in this tab is below:

<u>Grain (seed) fraction of reproductive biomass component</u>: Harvestable fraction of reproductive biomass. For grain crops the reproductive mass is the ratio of grain mass to reproductive mass (grain/(grain+chaff)). For corn the 'chaff' will include the husk and the shank. For many field crops a value of 0.8 is used.

<u>light extinction coefficient</u>: A measure of how much of the light energy is transmitted through a canopy. This parameter is a constant in the equation used to convert light energy into biomass. Values may range from 0.3 to 0.6 for crops with upright leaves, and from 0.6 to 1.05 for crops with horizontal leaves.

Ratio of heat units (start of senescence/total): This parameter determines when senescence will start (e.g. a value of 0.8 indicates that senescence will start when 80% of the growing season is completed).

maximum crop height: The height a plant can reach under ideal growing conditions.

<u>maximum root depth</u>: The depth that the root of a plant can reach under ideal growing conditions.

minimum temperature for plant growth: The average daily air temperature below which the model will not allow plant growth (the temperature stress factor is 0.0).

<u>optimal temperature for plant growth</u>: The average daily air temperature at which the model will allow maximum growth (the temperature stress factor is 1.0).

time of uninterrupted growth to maturity: This label is misleading and should be changed to read: days from planting to physiological (or market) maturity. For annual grain crops, the average number of days from planting to maturity of seed; for vegetable, fruit and root crops, sugarcane, and tobacco it is the number of days from planting (or ratooning) to harvest; for perennials (e.g. alfalfa) it is the number of days from spring growth to maturity of seed.

Growing degree days to maturity: For annual grain crops, the average seasonal growing-degree-days from planting to maturity of seed; for vegetable, fruit and root crops, sugarcane, and tobacco it is the average seasonal growing-degree-days from planting (or ratooning) to harvest; for perennials (e.g. alfalfa) it is the average seasonal growing-degree-days from spring growth to maturity of seed.

Biomass conversion efficiency: Energy to biomass conversion parameter at ambient CO_2 levels. This parameter determines how effective a crop is in converting photosynthetically active radiation into structural biomass. This parameter may be changed based on field experimentation.

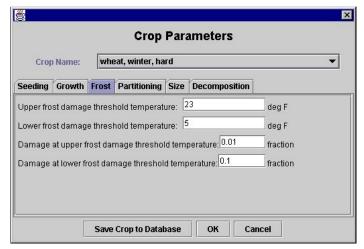


Figure 5.11. Frost tab window.

assistance.

Frost tab (Fig. 5.11): The Crop submodel reduces green leaf area in response to frost. The frost parameters determine the shape of a sigmoid curve used in assessing rate of green leaf area reduction in response to temperatures below freezing (Fig. 5.12).

Note: Changing parameters on the 'Frost' tab is not recommended unless the user completely understands their derivation and the resulting effect of the changes. Contact WERU for more

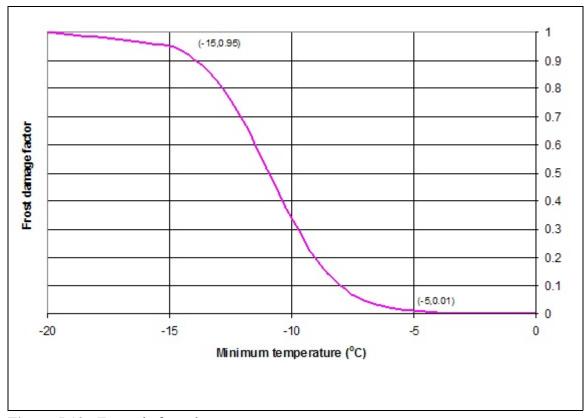


Figure 5.12. Example frost damage curve.

The frost parameters follow:

<u>Upper frost damage threshold temperature:</u> This label should be changed to read 'upper frost damage temperature'.

<u>Lower frost damage threshold temperature</u>: This label should be changed to read 'lower frost damage temperature'.

<u>Damage at upper frost damage threshold temperature</u>: This label should be changed to read 'relative damage at upper frost temperature'

<u>Damage at lower frost damage threshold temperature</u>: This label should be changed to read 'relative damage at lower frost temperature'.

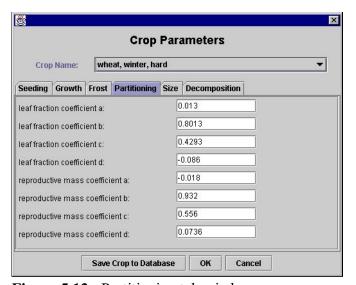


Figure 5.13. Partitioning tab window.

Partitioning tab (Fig 5.13): There 8 parameters in this tab. These parameters are the coefficients in a 4-parameter logistic function to determine partitioning of 'shoot' biomass into leaf or reproductive masses. The first 4 coefficients are for leaf biomass and the last 4 are for reproductive biomass (Fig. 5.14).

Note: Changing parameters on the 'Partitioning' tab is not recommended unless the user completely understands their derivation and the resulting effect of the changes. These parameters require extensive testing and or field data if new values are to be

generated and used. Contact WERU for more assistance. The parameters are:

<u>leaf fraction coefficient a</u>: The intercept of a 4-parameter logistic function used in computing the fraction of daily converted 'shoot' (above ground) biomass that goes into leaves.

<u>leaf fraction coefficient b</u>: The asymptote of a 4-parameter logistic function used in computing the fraction of daily converted 'shoot' (above ground) biomass that goes into leaves.

<u>leaf fraction coefficient c</u>: The inflection point of a 4-parameter logistic function used in computing the fraction of daily converted 'shoot' (above ground) biomass that goes into leaves.

<u>leaf fraction coefficient d</u>: The inverse of the slope of a 4-parameter logistic function used in computing the fraction of daily converted 'shoot' (above ground) biomass that goes into leaves.

<u>reproductive mass fraction coefficient a</u>: The intercept of a 4-parameter logistic function used in computing the fraction of daily converted 'shoot' (above ground) biomass that goes into reproductive parts or yield.

<u>reproductive mass fraction coefficient b</u>: The asymptote of a 4-parameter logistic function used in computing the fraction of daily converted 'shoot' (above ground) biomass that goes into reproductive parts or yield.

<u>reproductive mass fraction coefficient c</u>: The inflection point of a 4-parameter logistic function used in computing the fraction of daily converted 'shoot' (above ground) biomass that goes into reproductive parts or yield.

<u>reproductive mass fraction coefficient d</u>: The inverse of the slope of a 4-parameter logistic function used in computing the fraction of daily converted 'shoot' (above ground) biomass that goes into reproductive parts or yield.

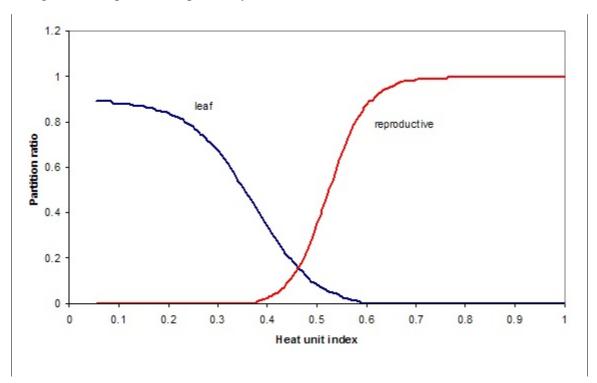
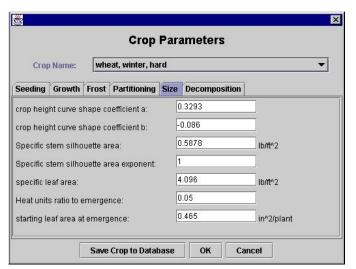


Figure 5.14. Example shoot and reproductive growth curves.



Size tab (Fig 5.15): Miscellaneous types of crop architecture parameters are contained in this tab.

Note: Changing parameters on the 'Size' tab is not recommended unless the user completely understands their derivation and the resulting effect of the changes. These parameters require extensive testing and or field data if new values are to be generated and used. Contact WERU for more assistance.

Figure 5.15. Size tab window.

The parameters are:

<u>crop height curve shape coefficient a</u>: The inflection point of a 2-parameter sigmoid function used to compute plant height.

<u>crop height curve shape coefficient b</u>: The inverse of the slope of a 2-parameter sigmoid function used to compute plant height (Fig. 5.<u>16</u>). These two parameters determine the potential rate of increase in plant height of a crop. The parameters are the result of assuming that plant height growth follows the growth patterns in leaf area. However, these parameters can also be derived from field measured plant height data.

Specific stem silhouette area: A slope coefficient of a power function.

<u>Specific stem silhouette area exponent</u>: For many crops, for which field data are available, it has been found that the relationship of stem silhouette area to its mass is strongly correlated to a 2-parameter power function. The power function is used in the model to compute stem silhouette area. The parameters are the coefficients of the power function. These parameters can be determined from field data of stem mass and stem silhouette area.

specific leaf area: The slope of a linear regression line of leaf mass vs leaf area. A zero-intercept linear function relating leaf mass to leaf area is used in the model to convert leaf mass to leaf area. This parameter can be determined from field data of leaf mass and leaf area.

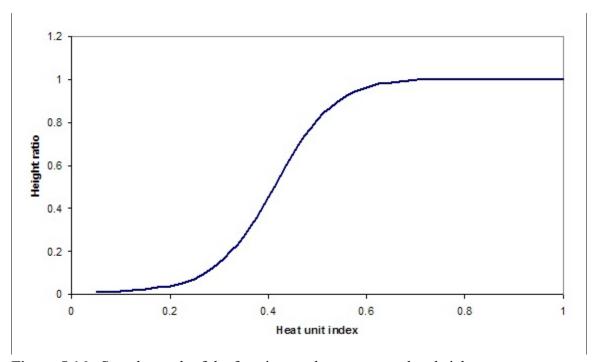
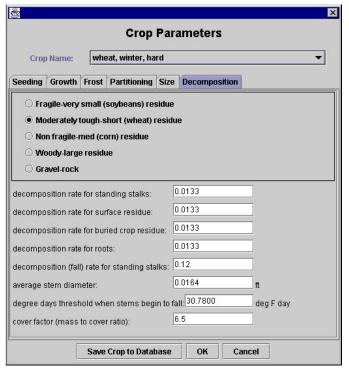


Figure 5.16. Sample graph of the function used to compute plant height.

<u>Heat unit ratio to emergence</u>: The relative heat units required for emergence. The model assumes that under average conditions it takes about 100 degree C days from seeding to emergence. The parameter is the ratio of degree C days from seeding to emergence to the degree C days from seeding to maturity.

starting leaf area per plant at emergence: The average estimated leaf area per plant when seedling emerges from the ground (inches^2/plant).



Decomposition tab (Fig 5.17): Five options are available for selecting decomposition parameters for surface and buried residue. They range from fragile to non-erodible types depending on the crop type.

Note: Changing parameters on the 'Decomposition' tab is not recommended unless the user completely understands their derivation and the resulting effect of the changes. These parameters require extensive testing and or field data if new values are to be generated and used. Contact WERU for more assistance.

Figure 5.17. Decomposition tab window.

Parameters for each option are:

decomposition rate for standing stalks: Standing residue mass decomposition rate (g/g/day).

decomposition rate for surface residues: Flat residue decomposition rate (g/g/day).

decomposition rate for buried crop residue: Buried residue decomposition rate (g/g/day).

decomposition rate for roots: Root residue mass decomposition rate (g/g/day).

<u>decomposition</u> (fall) rate for standing stalks: The rate at which standing stalks fall to a flattened (horizontal) position on the soil surface.

average stem diameter: Residue stem diameter (meters or feet).

degree days threshold when stems begin to fall: Threshold degree C days (degree C days).

cover factor (mass to cover ratio): kg m⁻²

Management Database

Appendix 3: Flags and Command Line Options

Submodel Report Flags

To generate various kinds of reports, a flag must be set. To set the option through the interface use the output tab of the Configuration screen. A flag number is entered in the box in the appropriate submodel. A flag of zero, '0', will result in no output generated to the listed file. It should be noted that generating these files may create large file sizes and significantly slow the execution of the WEPS model.

Submodel & flag no.	file name(s)	description
Hydrology 0 1 2 3 4 5 6 7	hydro.out water.out hydro.out & water.out temp.out temp.out & hydro.out temp.out & water.out temp.out & water.out	no output generated daily output hourly output for each day generates both files daily soil temperature output by layer generates both files generates both files generates all three files
Soil 0 1	soil.out	no output generated daily submodel output
Management 0	manage.out	no output generated daily submodel output
Crop 0 1	crop.out	no output generated daily submodel output
Decomposition 0 1 2 3	dabove.out dbelow.out dabove.out & dbelow.out	no output generated daily above ground submodel output daily below ground submodel output generates both files

5.48 APPENDIX 3: FLAGS AND COMMAND LINE OPTIONS WEPS

Erosion 0 no output generated 1 erosion.out currently generates an empty file eegt.out currently generates an empty file eros.tmp currently generates an empty file subday.out daily wind direction and subdaily (i.e., hourly) wind speeds

A flag of one, '1', for any submodel generates the file 'plot.out' which contains a variety of output variables on a daily basis. This file is suitable for input into spreadsheets or plotting packages for plotting of daily data. See the header of the file or contact the WEPS developers for more information on the variables output to 'plot.out.

Command Line Options

Windgen 4

```
Usage: wind gen4 -D -V -v -h -l -f dbfile -o outfile -s # -x # -r # -b # -v #-u # -d # -?
                       debug flag
       -D
       -V
                       display version and exit
                       set the verbose option
       -V
                       do not display output title heading
       -h
                       display long (additional) output
       -1
       -f dbfile
                       specify wind database file (wind gen.wdb)
                       specify output file (stdout)
       -o outfile
                       specify station WBAN no.
       -s #
                       specify station database index no.
       -x #
                       specify random number seed (54321)
       -r #
                       specify beginning simulation (calendar) year (1)
       -b #
                       specify number of years to simulate (1)
       -v#
       -u #
                       specify storm duration length in hours (6)
                       specify number of days to build storms from (5)
       -d #
```

Wind station WBAN code number required Note that only the "-f" option with the location of the appropriate wind_gen database file to access is required for WEPS 1.0. All other options are either automatically added internally by WEPS 1.0 or are optional. Those that WEPS 1.0 automatically sets are:

```
-s #
-y #
-o outfile
```

Those that can be added to the command line and should work within WEPS 1.0 are (NOTE that I haven't verified them - lew):

- -D
- -v
- -x #
- -r#
- -b#
- -u #
- -d #

Those that can't be specified when wind gen4 is run within WEPS 1.0 are:

- -V
- -1
- -h
- -?

Cligen Version 5.2254

CLIGEN V-5.2254 - Climate Generator w/ QC-SNDG

Usage: cligen -S -s -I -o -b -y -f -F -H -r -t -I# -v -V-? -O

- -S<state number>
- -s<station ID number>
- -i<input file name>
- -o<output file name>
- -b
beginning year>
- -y<duration in years>
- -f old WEPS record format
- -F overwrite output file if it exists
- -H omit header output
- -r<random seed>
- -t<Sim Type (WEPP: 4=SglStm, 5=Contin)>
- no interpolation (default) -I0
- -I1 linear interpolation
- -I2 Fourier interpolation
- -I3 interpolation to preserve avgs
- -V
- -V verbose
- -h, -?, -\\?, /h help
- -O<option 6 observed data filename>

Make sure there are no spaces between each flag and its parameter. If command line options are omitted, CLIGEN will interactively request the required information.

Note that the "-I" option with the location of the appropriate cligen database file to access, the "-b" option specifying the start year (usually 1), "-t" option with value "5", and the "-F" option are all required for WEPS 1.0. All other options are either automatically added internally by WEPS 1.0, are optional, or not applicable when used with WEPS 1.0.

Those that WEPS 1.0 automatically sets are:

- -S#
- -s#
- -y#
- -ooutfile

Those that can be added to the command line and should work within WEPS 1.0 are (NOTE that I haven't verified them - lew):

- -r#
- -10
- -I1
- -I2
- -I3
- -V

Those that can't be specified when cligen5110 is run within WEPS 1.0 are:

- -v
- -h
- -?
- -t# (with options values other than 5)

WEPS 1.0

```
Usage: weps -? -C# -E# -I# -L# -l# -w# -O# -R# -S# -s# -Y -P./
```

Valid command line options:

- -? Display the help screen
- -h Display the help screen
- -C WEPS crop calibration mode
 - 0 = Do not run crop calibration (default)
 - 1 = Run crop calibration

- -E Simulate \"erosion\" in WEPS run
 - 0 = Do not run the erosion submodel
 - 1 = Run the erosion submodel (default)
- -I Specify if initialization is done and if so, the # loops
 - 0 = No initialization
 - 1 = Runs one management cycle (default)
 - 2 = Runs x management cycles
- -L Specify soil layer thickness to scale layer splitting (mm)

Specify -L2 for layer splitting to use 2 mm (no decimals)

-1 Specify rate of soil layer thickness increase with depth for

layer splitting in percent increase of layer thickness

- Specify -150 to 50 percent for each layer (no decimals) -w Specify method of weighting for layer conductivity and flow
 - 0 = arithmetic mean method
 - 1 = unweighted 0.5 method (default)
 - 2 = Uses internodal method
- -O Generate stand alone erosion input file on simulation day Specify -O2932 to output file on simulation day 2932
- -o Generate stand alone erosion input file on DD/MM/YY

Specify -0020901 to output file on day 2 month 9 year 1

Day and month must be 2 digits, Year can be 1 to 4 digits

-P Specify path to WEPS project run directory

Must be specified if other command line switches are used

Must be the last option specified

Specifying only the path without the \"-P\" option only works if no other command line switches are specified - e.g: \"weps path to weps.run file\"

- -R WEPS debug messages dumped to screen
 - 0 = no debug messages sent to screen
 - 1 = 1st level debug messages sent to screen
 - 2 = 1st and 2nd level debug messages sent to screen
 - 3 = 1st, 2nd, and 3rd level debug messages sent to screen
- -S Vary type of value input for 1/3 bar, 15 bar water
 - 0 = 1/3bar(vol) 15bar(vol)
 - 1 = 1/3bar(vol) 15bar(grav)
 - 2 = 1/3bar(grav) 15bar(grav)
 - 3 =use texture based calc (default)

Override 1/3bar, 15bar, bulk density w/ texture estimate

- -s Specify soil ifc file input format type
 - 0 = new format (additional parms)
 - 1 = old format
- -Y Optional functional Yield/residue ratio

0 = Use full staged biomass partitioning

1 = Use functional Yield/residue ratio (default)

Default options are set to:

```
-I1 -S3 -s1 -R0 -Oo(no file) -E1 -C0 -Y1 -L1 -l25 -w1 -P./
```

Note that only the "-P" option is required for WEPS 1.0. (It must be the last option specified if more than one option is listed because WEPS 1.0 appends the current WEPS Project Run directory path prior to executing the WEPS science model.

The options that the WEPS 1.0 interface set automatically are:

-Ppath

WEPS 1.0 assumes that the user has specified the "-P" (as the last option) within the WEPS 1.0 configuration panel without the "path". WEPS 1.0 appends the path of the current WEPS Project Run directory prior to executing the WEPS science model.

Those that can be added to the command line and should work within WEPS 1.0 are (NOTE that I haven't verified them - lew):

- -I#
- -S#
- -s#
- -R#
- -O
- -0
- -E#
- -C#
- **-**Y#

Those that can't be specified when run within the WEPS 1.0 interface are:

- -h
- -?

Appendix 4: Using WEPS with Measured Data

Introduction

The Wind Erosion Prediction System (WEPS) is designed to simulate soil loss by wind from cultivated fields by simulating weather and field conditions (Wagner, 1997). However, in some situations, WEPS may be run using measured or simulated data from other models. This is typically done to validate various components or submodels of WEPS, particularly the erosion portion of the model. For example, a user may have measured soil loss data and limited weather and soil data. This user can input the measured weather and soil data to compare the model soil loss with the measured loss. This section will explore the use of WEPS with measured or other simulated data.

WEPS is a process-based, continuous, daily time-step model that simulates weather, field conditions, and erosion by wind. It has the capability of simulating spatial and temporal variability of a field's soil, crop, and residue conditions and soil loss/deposition within a field. The saltation/creep, suspension, and PM10 components of eroding material are also reported separately by direction. The WEPS model is modular in design with submodels that simulate weather, soil conditions, crop growth, residue decomposition, management operations, and soil loss by wind. It is designed to be used by the USDA-NRCS, under a wide range of conditions throughout the U.S. However, with proper inputs, WEPS is easily adapted to other parts of the world.

In typical applications, input files are created within the user interface which supplies these files to the science portion of the model to calculate field conditions and erosion. WEPS requires the following input files for a simulation run; a 'Run file', Windgen file', 'Cligen file', 'Soil file', and a 'Management file'. These files can be modified with measured or other data and run with WEPS under certain constraints. All input files except the Management file, may be easily altered using a standard text editor or the WEPS user interface to reflect measured data. All input files must be formatted to meet the requirements for WEPS. A description of these input files and considerations for their creation with measured data are given below.

It is important to note that the purpose of the WEPS model is to simulate changes in field conditions as a result of management and weather to estimate wind erosion. To simulate these changes in field conditions, WEPS is intended for simulations of multiple day periods of time. If one desires to simulate only a single storm, field conditions are essentially static and the full WEPS model is not necessary. To simulate single erosion events of one day or less, the standalone erosion submodel is recommended. The use of the standalone submodel is also described below.

WEPS can be run from either the interface or the command line. Typically, users will run the model through the interface where modified input files can be selected. See the individual input file descriptions below for information on how to select modified files within the interface. Some input files are best modified within the interface (e.g., soil and management files) while others require some sort of separate editing or creation with a separate program (e.g., weather files). Files that are modified by the user but input via the interface must be placed in the appropriate project directory (i.e., folder). Those wishing to run WEPS via the command are advised to see the section titled "Report Flags and Command Line Options" in the WEPS User Manual.

Output files obtained from WEPS are described elsewhere in the WEPS User Manual. For assistance using measured data with WEPS, please go to {http://www.weru.ksu.edu/weps}.

Run File

The default file name of the WEPS run file is 'weps.run'. This file contains general information for a simulation run including the dates of the simulation, the field and barrier dimensions, the field location, and the path and names of the other input files (described below). The 'run file' parameters can be modified to match the parameters for the field simulated. The list of the other input files should specify the path and name of measured data to be used. This file contains comments (indicated by a '#' in column one) which describes each line of input data to aid in checking and modifying input data.

Below is a description of the items required in the Run File of WEPS. An example Run File is shown in Figure 5.18. Note that lines beginning with '#' character are comment lines. Lines beginning with '# RFD' are comments used by the interface. Some of the parameters are critical to the science model (SC), some are critical to the operation of the interface (IC), some are critical to both (SC+IC), while others are not critical to either (NC). An example of non-critical parameters would include the User Name which does not affect the operation of WEPS and is used for informational purposes only. In all cases however, some sort of 'placeholder' is required, even for non-critical parameters. In other words, blank lines are not allowed and each expected line should be present and filled with some characters.

The interface is a simple way to input data into the Run file and is recommended. The information below is presented for the benefit of those users who wish to modify the input file themselves.

Run File Parameters:

--USER INFORMATION

UserName - This character variable holds the user name. (NC)

FieldNo - This character variable is a part of a field tract that is separated by permanent boundaries. (NC) Note that FieldNo, TractNo, FarmNo, RunMode, RunCycle, and RotCycle are all entered on one line with each parameter separated by the pipe "|" symbol.

TractNo - This character variable is often used by FSA and NRCS to identify a field. (NC)

FarmNo - This character variable is a farm identification number. (NC)

RunMode - This character variable specifies the type of run length as either the NRCS method (specifies a fixed number of cycles), use simulation run start and end dates on the main screen, or specify the use of management rotation cycles on the main screen. (IC)

RunCycle - This variable specifies the number of management rotation cycles to simulate in a WEPS run. (IC)

RotCycle - This character variable specifies the number of years in the rotation cycle. (IC)

SiteCounty and SiteState - This character variable specifies the county and state to be simulated. (NC)

--SITE INFORMATION

LatitudeSign - This parameter is used to specify the specify the hemisphere of the latitude. Enter a plus sign (+) for the Northern hemisphere and a minus sign (-) for the Southern hemisphere. (IC)

Latitude -The latitude of the location modeled in degrees and fraction of degrees. The CLIGEN and WINDGEN stations nearest to the center of the location county will then be determined by the interface and listed. Latitude is also used by the science model to determine day length and time of sunrise. (SC+IC)

LongitudeSign - This parameter is used to specify the specify the hemisphere of the longitude. Enter a plus sign (+) for the Eastern hemisphere and a minus sign (-) for the Western hemisphere. (IC)

Longitude -The longitude of the location modeled in degrees and fraction of degrees. The CLIGEN and WINDGEN stations nearest to the center of the location county will be determined by the interface. Longitude is used by the science model to determine day length

as well as time of sunrise. (SC+IC)

Elevation (meters) - The average elevation for the location to be modeled in the units of measure displayed on the screen (feet or meters). The science model requires elevation in meters and converts feet to meters. (SC+IC)

CliGenStationID - The name of the CLIGEN station used to generate many of the weather parameters for WEPS. (IC)

WindGenStationID - The name of WINDGEN station used to generate the wind parameters for WEPS. (IC)

--SIMULATION PERIOD

StartDate (day, month, year) - The "Start Date" is the date from which you want the simulation to begin. The format is the numerical value for day, month (e.g., 03 for March), and year (two or four characters), each separated by a blank space. (SC+IC)

A typical run begins on January 1 and ends on December 31 with multiple years of simulation. However, for those using WEPS with historical data, other start and ending days and months may be entered. The correctness of output has not been tested in these situations.

EndDate (day, month, year) - The "End Date" is the date on which you want the simulation to end. The format is the numerical value for day, month (e.g., 03 for March), and year (two or four characters), each separated by a blank space. (SC+IC)

A typical run begins on January 1 and ends on December 31 with multiple years of simulation. However, for those using WEPS with historical data, other start and ending days and months may be entered. The correctness of output has not been tested in these situations.

TimeSteps (per day) - The number of time steps per day used for the daily distribution of simulated wind speed for erosion calculations. If none is entered through the interface Configuration Screen, the number of time steps is assumed to be 24. (SC)

--RUN FILE NAMES (INPUT)

climate file - This character variable holds the path and CLIGEN input file name. (SC+IC)

wind file - This character variable holds the path and WINDGEN input file name. (SC+IC)

soil file - This character variable holds the path and soil input file name. (SC+IC)

management file - This character variable holds the path and management input file name. (SC+IC)

--WEPS OUTPUT OPTIONS

OutputFile - This character variable holds the path and general output file name. (SC+IC)

ReportForm - This variable was intended to hold six (6) flags for selecting various general report forms but is not used in the current version of WEPS. (NC)

OutputPeriod - This variable was intended to hold a flag for selecting the period of output but is not used in the current version of WEPS. (NC)

SubmodelOutput - This variable holds numerical flags to print detailed reports for various submodels. Submodel detail report flags are described elsewhere in the WEPS User Manual. (SC+IC)

DebugOutput - This variable holds numerical flags to print debug reports for various submodels. Submodel debug report flags are described elsewhere in the WEPS User Manual. (SC+IC)

--SIMULATION REGION INFORMATION

RegionAngle (degrees from North) - This is the angle of the field with respect to North. (SC enter angle 0-360 decrees, clockwise from North) or (IC enter angle up to \pm 45 degrees)

SimCoords1 (meters) - These two variables hold the X and Y coordinates of the origin of the simulation region. This is typically the lower left corner for the North-South oriented rectangular simulation region. (SC+IC)

SimCoords2 (meters) - These two variables hold the X and Y coordinates of the opposite corner of the simulation region (furthest from the origin). This is typically the upper right corner for the North-South oriented rectangular simulation regions. (SC+IC)

ScaleFactors - These two variables were intended to hold scale factors for displaying the simulation region in the interface but is not used in the current version of WEPS. (NC)

AcctRegNo - This variable holds the number of accounting regions in the simulation region. If more than one accounting region is present (i.e., AcctRegNo > 1), then the accounting region coordinates are repeated in succession to account for each accounting region. (SC+IC)

AcctCoords1 (meters) - These two variables hold the X and Y coordinates of the origin of the accounting region. This is typically the lower left corner for the North-South oriented

rectangular accounting region. (SC+IC)

AcctCoords2 (meters)- These two variables hold the X and Y coordinates of the opposite corner of the accounting region (furthest from the origin). This is typically the upper right corner for the North-South oriented rectangular accounting regions. (SC+IC)

SubRegNo - This variable holds the number of subregions in the simulation region. If more than one accounting region is present (i.e., SubRegNo > 1), then the subregion coordinates are repeated in succession to account for each subregion. (SC+IC)

SubCoords1 (meters) - These two variables hold the X and Y coordinates of the origin of the current subregion. This is typically the lower left corner for the North-South oriented rectangular subregion. (SC+IC)

SubCoords2 (meters) - These two variables hold the X and Y coordinates of the opposite corner of the subregion (furthest from the origin). This is typically the upper right corner for the North-South oriented rectangular subregions. (SC+IC)

AverageSlope (%) - The average slope of the subregion. This information is now obtained from the soil input file. (NC)

-- BARRIERS

NumberBar - This variable holds the number of barriers in the simulation region. If more than one barrier is present (i.e., NumberBar > 1), then the barrier information (i.e., barrier coordinates and parameters) are repeated in succession to account for each barrier. (SC+IC)

BarrierCoords1 (meters) - These two variables hold the X and Y coordinates of the origin of the barrier. This is typically the lower left corner of the barrier. (SC+IC)

BarrierCoords2 (meters) -These two variables hold the X and Y coordinates of the opposite corner of the barrier (furthest from the origin). This is typically the upper right corner of the barrier. (SC+IC)

BarrierType - This character variable specifies the name of the type of barrier. (NC)

BarrierHeight (meters) - This parameter is the barrier average height. (SC+IC)

BarrierWidth (meters) - This parameter is the barrier average width (not length). (SC+IC)

BarrierPorosity (%) - The barrier porosity is expressed as an optical porosity. It is the open space as viewed looking perpendicular through the barrier expressed as a percent of the total area (ie., $((1.0 - \text{silhouette area}) \times 100)$).

Figure 5.18. Example Run file.

```
#----- WEPS SIMULATION RUN FILE -----
# Note: Lines beginning with '#' are comment lines.
       Lines beginning with '# RFD' are comments used by the interface.
#
# --USER INFORMATION
  RFD-UserName
Dustin Fields
  RFD-FieldNo RFD-TractNo RFD-FarmNo RFD-RunMode RFD-RunCycle RFD-RotCycle
789 | 456 | 123 | cycle | 2 | 2
  RFD-SiteCounty and SiteState
Finney, Kansas
# --SITE INFORMATION
# RFD-LatitudeSign RFD-Latitude
+38.00
# RFD-LongitudeSign RFD-Longitude
-100.66
   RFD-Elevation (meters)
801
   RFD-CliGenStationID
CIMARRON
# RFD-WindGenStationID
GARDEN CITY MUNI
# --SIMULATION PERIOD
# RFD-StartDate (day month year)
01 01 01
  RFD-EndDate (day_month_year)
31 12 4
   RFD-TimeSteps (per_day)
#
24
# --RUN FILE NAMES (INPUT)
  RFD-climate file
cli_gen.cli
# RFD-wind file
win_gen.win
# RFD-sub-daily file
none
# RFD-SoilFile
Otero 1010F 100 FSL.ifc
  RFD-ManageFile
KS_wheat_fallow.man
# --WEPS OUTPUT OPTIONS
# RFD-OutputFile
output.tmp
#
  RFD-ReportForm
0 0 0 0 0 0
   RFD-OutputPeriod
  RFD-SubmodelOutput
0 0 0 0 0
  RFD-DebugOutput
0 0 0 0 0
# --SIMULATION REGION INFORMATION
#
   RFD-RegionAngle (deg_clockwise_north)
21
```

```
RFD-SimCoords1 (meters)
0.0 0.0
# RFD-SimCoords2 (meters)
1500.2 1500
# RFD-ScaleFactors (place holder - needed for older versions of WEPS)
5.5 5.5
#
   RFD-AcctRegNo
  RFD-AcctCoords1 (meters)
#
   0.0 0.0
  RFD-AcctCoords2 (meters)
1500.2 1500
#
#
   RFD-SubregionNo
1
#
   RFD-SubCoords1 (meters)
0.0 0.0
# RFD-SubCoords2 (meters)
1500.2 1500
#
  RFD-AverageSlope (%)
0.50
# --BARRIERS
# RFD-NumberBar
2
#
  RFD-BarrierCoord1 (meters)
-1 0
# RFD-BarrierCoords2 (meters)
0 1500
  RFD-BarrierType
#
Snow fence
  RFD-BarrierHeight (meters)
1.2
  RFD-BarrierWidth (meters)
1
#
   RFD-BarrierPorosity (%)
0.6
# RFD-BarrierCoord (meters)
0 -2
1500.2 0
# RFD-BarrierType
Sorghum (2 row)
   RFD-BarrierHeight (meters)
  RFD-BarrierWidth (meters)
2
#
   RFD-BarrierPorosity (%)
0.5
#---- END OF SIMULATION RUN FILE -----
```

Weather Files

WEPS runs are made for multiple years in full year increments beginning on January 1. If only a partial year of weather data is available (typical), the user has two options. One option is to substitute measured data within the simulated weather file for the desired location and observe the output for the period with measured data. For this option, the user should note that the field conditions cannot be input into the simulation at the point the measured data begins (although future versions of WEPS with this capability are planned). The field conditions will be the result of the simulation up to that point and may not exactly match actual field conditions for the measured data site. The second option is to use the stand alone Erosion model (described below) for single day simulations. Two weather files are required by the full WEPS model, a Windgen file and a Cligen file.

If alternative weather files are to be used in the full WEPS model, they are input through the interface. Alternative weather files are designated by first checking the appropriate wind or climate box in the "Run" tab of the "Configuration" window. Then enter the file name and path or choose the file by clicking the folder icon on the "Location Information" panel of the main screen.

Windgen File

The Windgen file extension is "win" (e.g., wind_gen.win). This file contains both the wind speed (m s⁻¹) on a subdaily time step and one wind direction (degrees clockwise from North) for each day of the simulation. If more than one wind direction is measured for the day (typical), an average wind direction should be calculated. A wind direction can be calculated using average weighted by wind speed. This weighting is recommended to provide more weight to stronger, erosive winds. Average wind direction for a day is calculated as:

$$Ue = \sum_{i=1}^{k} (Si * \sin Ti)$$
 [5.1]

$$Un = \sum_{i=1}^{k} (Si * \cos Ti)$$
 [5.2]

$$Tu = \arctan \frac{Ue}{Un}$$
 [5.3]

where,

k = number of directions per day,

Si = wind speed (any units),

Ti = wind directions (0 - 360 degrees),

Tu = average wind direction (0 - 360 degrees). If Tu < 0, then Tu = Tu + 360.

The subdaily wind speeds are by default the average hourly speeds (i.e., 24, 1-hour averages of point measurements) but can be of other time steps of equal length (e.g., 96, 15-minute averages of point measurements) if specified in the weps.run file. If data re available, it is recommended that time steps less than or equal to1-hour be used with the smaller the time step (more periods) being more accurate representation of the true winds. Also, the height of the wind measurement in WEPS is assumed to be 10 meters. If wind speeds were taken at a height other than 10 meters, speeds should be adjusted to what they would be at a 10 meter height. WEPS ignores the Windgen file header information which is in the first seven rows. Below is a description of the lines and columns required by WEPS as well as an example Windgen file (Figure 5.19).

Windgen File Parameters:

Lines 1 - 7: Comment lines (ignored). These do not need to be filled out but

WEPS does need to have these seven lined present with a '#' at the

beginning of the line.

Line 8 +: wind data, one day at a time as described below.

Items 1, 2, 3: day mo year - the day, month, and year of simulation (integer).

Item 4: **dir** - wind direction for the day. WEPS assumes that the direction is

constant for the day (real- degrees clockwise with North = 0.0, East

= 90.0, South = 180.0, etc.).

Items 5 - end: **hr1 hr2 hr3...** - average 1-hour wind speeds, distributed throughout

the entire day. These represent by default, twenty-four, 1-hour average wind speeds (real-meters/second). If other time steps are used they should be of equal length and the number of these periods

specified in the weps.run file.

1	#								ırly va	lues	per day	outp	ut			
2	#	sta	tion	: 1	13985 D	ODGE_CI	TY, KS	S USA								
3					eg 46m					W						
4	#	per	iod:	19	610421	-197812	31 el	l: 796m	1							
5	#	day	mo	yea	ar dir	hr1	hr2	hr3	hr4	hr5	hr6	hr7	hr8	hr9		
6	#				deg	m/s	m/s	m/s	m/s	m/s	m/s	m/s	m/s	m/s		
7	# -														 	
8			1	1	0.0	3.7	4.7	6.1	6.4	6.9	7.7	8.3	9.3	14.4		
9		2	1	1	180.0	3.5	4.7	5.5	5.8	6.4	6.9	7.5	7.9	8.5		
10		_	1	1	0.0	3.7	4.7	6.1	6.4	6.8	7.7	8.1	9.3	12.1		
11		4	1	1	157.5	2.9	3.5	4.1	4.3	4.6	5.0	5.4	5.6	7.4		
12		5	1	1	135.0	2.3	2.9	3.5	3.8	4.5	4.8	5.4	6.0	8.2		
13		6	1	1	22.5	3.5	4.6	5.2	5.8	6.6	7.2	7.9	8.8	11.0		
14		7	1	1	180.0	3.8	4.9	5.6	5.8	6.5	7.1	7.7	8.0	9.4		
15		_	1	1	202.5	4.0	4.8	5.2	5.7	5.9	6.2	6.7	7.2	8.1		
16		9	1	1	22.5	3.5	4.6	5.1	5.8	6.4	7.1	7.7	8.8	10.3		
17	1	0	1	1	135.0	2.1	2.8	3.4	3.8	4.4	4.7	5.3	5.8	6.7		
18	1	1	1	1	202.5	4.2	5.0	5.3	5.7	5.9	6.4	6.9	7.4	9.5		
19	1		1	1	337.5	3.1	3.6	4.4	4.9	5.5	6.5	7.1	8.0	9.0		
20	1	3	1	1	270.0	3.0	3.3	3.8	4.2	4.6	4.8	5.0	5.5	6.3		
21	1	4	1	1	0.0	3.6	4.4	5.7	6.3	6.6	7.2	7.9	9.0	10.1		
22	1	5	1	1	0.0	3.7	4.5	6.1	6.3	6.7	7.7	8.0	9.1	11.3		
23	1	6	1	1	157.5	2.5	3.4	3.9	4.3	4.5	4.9	5.2	5.6	6.1		
24	1	7	1	1	292.5	3.4	4.0	4.3	4.6	5.2	5.4	5.8	6.2	7.2		
25	1	8	1	1	22.5	3.3	4.5	5.0	5.6	6.2	7.0	7.7	8.5	9.0		
26	1	9	1	1	157.5	3.0	3.6	4.1	4.4	4.7	5.1	5.4	5.7	8.2		
27	2	0	1	1	180.0	3.8	4.8	5.6	5.8	6.4	7.0	7.7	8.0	8.9		
28	2	1	1	1	0.0	3.7	4.4	6.0	6.3	6.7	7.5	8.0	9.1	10.5		
29	2	2	1	1	22.5	3.5	4.7	5.2	5.8	6.6	7.3	8.0	8.9	11.7		
30	2	3	1	1	270.0	3.1	3.4	3.9	4.2	4.6	4.8	5.0	5.5	6.5		
31	2	4	1	1	135.0	2.0	2.8	3.4	3.7	4.2	4.7	5.3	5.8	6.5		
32	2	5	1	1	157.5	2.7	3.5	4.0	4.3	4.5	5.0	5.2	5.6	6.9		
33	2	6	1	1	22.5	3.4	4.6	5.1	5.7	6.2	7.1	7.7	8.6	9.7		
34	2	7	1	1	180.0	3.8	4.9	5.6	6.0	6.6	7.1	7.7	8.0	10.0		
35	2	8	1	1	315.0	2.8	3.5	4.1	4.5	4.9	5.5	6.1	6.4	7.1		٠
36	2	9	1	1	202.5	4.0	4.9	5.2	5.7	5.9	6.2	6.7	7.2	8.4		٠
37	3	0	1	1	247.5	2.6	3.1	3.6	4.2	4.5	4.9	5.2	5.6	6.7		
38	3	1	1	1	0.0	3.7	4.4	5.9	6.5	7.4	8.2	9.2	10.1	12.2		
39																
40																
41																

Cligen File

The default Cligen file extension is "cli" (e.g., cligen.cli). The Cligen weather generator was developed for use with the Water Erosion Prediction Project (WEPP) (Flanagan, et.al., 2001) and is used by WEPS to simulate other weather parameters. The input file created by Cligen includes precipitation amount (mm), duration (hr), time to peak (fraction of duration), and peak intensity (mm hr⁻¹) as well as maximum and minimum air temperature (°C), solar radiation (ly d⁻¹), and dew point temperature (°C). This file also contains historical monthly averages for maximum and minimum temperature (°C) which are required by WEPS.

Although WEPS ignores non-needed data in the Cligen file, WEPS reads the entire file so each line and column in WEPS must be populated even though some elements may be 'dummy' variables not used by WEPS. For example, line 2 contains information not used by WEPS but must be present with any characters present. The Cligen file is read in free format. Below is a description of the lines and columns WEPS requires as well as an example Cligen file (Figure 5.20).

Cligen File Parmeters:

Line 1: Cligen version number. Must be "5.110" for the file format described in this document.

Lines 2-6: Information in these lines are not required by WEPS but must be present as place holders.

Line 7: Observed monthly ave maximum temperatures (°C).

Line 8 Comment line.

Line 9: Observed monthly ave minimum temperatures ©).

Lines 10-15: Comment lines.

Line 16 +: daily weather data.

Columns 1, 2, 3: day mon year - the day, month, and year of simulation (integer).

Column 4: **prcp** - total precipitation for the day including snow, hail and rain (real-milimeters).

Column 5: **dur** - duration of the rainfall event (real-hours).

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Column 6: **tp** - fraction of time to peak (real-time to peak in hours/duration in hours).

Column 7: **ip** - WEPP data, ignored in WEPS but must have some numbers present (e.g., 0.0)(real).

Columns 8, 9: tmax tmin - the maximum and minimum daily air temperature (real - C).

Column 10: **rad** - daily solar radiation (real - ly/day).

Columns 11-12: WEPP wind data, ignored in WEPS but numbers must be present (e.g., 0.0) (real).

Column 13: **dew** - dew point temperature (real - C).

Figure 5.20. Example Cligen File.

```
Station: CIMARRON KS
                                                     CLIGEN VERSION 5.110 -r:
   Latitude Longitude Elevation(m) Obs. Years Beginning year Years simulated Command Line:
   37.80 -100.35 801 54
                                          1
                                                           6
                                                               -S14 -s1522 -idb\cligen fs.db -b1
   Observed monthly ave max temperature (C)
    6.9 10.1 14.5 20.8 25.3 31.1 34.2 33.2 28.8 22.8 13.8 8.3
   Observed monthly ave min temperature (C)
   -8.1 -5.8 -2.1 4.1 9.8 15.3 18.0 17.0 12.2 5.3 -2.4 -6.7
10 Observed monthly ave solar radiation (Langleys/day)
   253.0 317.0 420.0 525.0 564.0 643.0 635.0 578.0 491.0 374.0 307.0 234.0
   Observed monthly ave precipitation (mm)
   14.3 17.0 33.6 48.3 90.9 89.8 87.2 68.4 45.1 37.0 21.5 13.4
                              ip tmax tmin rad w-vl w-dir tdew
14
   da mo year prcp dur tp
                                   (C) (C) (1/d) (m/s) (Deg)
              (mm)
                   (h)
              0.0
                   0.00 0.00
                             0.00
                                   3.9 -2.6 250.
                                                  5.5 75.
           1
              0.0
                   0.00 0.00
                              0.00
                                   -2.5 -5.5 143.
                                                  6.0
                                                       297.
              0.0
                   0.00 0.00
                              0.00
                                    0.3 -4.0 219.
                                                  8.2
                                                       238.
              0.0
                   0.00 0.00
                              0.00 17.8 -10.2 253.
                                                  4.0
                                                       227.
              0.0
                  0.00 0.00
                              0.00
                                    6.3 -12.3 254.
                                                  5.9
                                                       314.
              0.0 0.00 0.00
                              0.00 15.3 -3.6 148.
                                                   8.3
                                                       238.
              0.0 0.00 0.00
                              0.00
                                    0.5 -10.2 257.
                                                   7.0
                                                       23.
              0.4 1.66 0.01
                              1.01
                                   13.9 -14.2 258.
                                                   7.9
                                                       355.
   9
              0.0 0.00 0.00
                              0.00
                                    7.1 -5.6 230.
                                                  2.6 328.
   10
              0.0 0.00 0.00
                              0.00 10.1
                                        -6.2 283.
                                                  8.6
                                                       49.
   11
      1
              0.0 0.00 0.00
                              0.00
                                   10.0 -9.0 263.
                                                  0.0
                                                        7. -20.9
           1
   12
      1
           1
              0.0 0.00 0.00
                              0.00
                                    2.8 -12.2 231.
                                                  6.9 222.
                                                  1.2
   1.3
      1
           1
              0.0 0.00 0.00
                              0.00
                                   -0.3 -14.1 267.
                                                       317.
29 14
      1
           1
              0.0 0.00 0.00
                              0.00
                                   -4.0 -6.7 173.
                                                  3.4
                                                       313.
30 15
      1
           1
              0.0 0.00 0.00
                              0.00
                                   -1.7 -14.8 270.
                                                  2.7
                                                       132.
   16
              2.3 1.29 0.04
                              1.01
                                    0.6 -4.9 262.
                                                  9.9
                                                       15.
   17
              0.0 0.00 0.00
                              0.00
                                    6.0
                                        -5.0 241.
                                                   7.0
                                                       338.
   18
              0.0 0.00 0.00
                              0.00
                                    7.8 -9.1 203.
                                                   4.2
                                                       262.
34
   19
              0.0 0.00 0.00
                              0.00
                                   12.3 -10.5 181.
                                                   3.7
                                                       275.
35 20
              0.0 0.00 0.00
                              0.00
                                   -8.9 -10.5 266.
                                                   6.0
36 21
              0.0 0.00 0.00
                              0.00 14.7 -9.8 283.
                                                  5.7
                                                       264.
37 22
              0.0 0.00 0.00
                              0.00
                                   3.9 -8.0 132.
                                                  3.5
                                                       233.
38 23
      1
              0.0 0.00 0.00
                              0.00 11.2 -10.0 196.
                                                   4.9
                                                       150.
           1
39 24
      1
              0.0 0.00 0.00
                              0.00
                                    2.3 -15.9 230.
                                                  4.6
                                                       136.
           1
40 25
      1
           1
              0.0 0.00 0.00
                              0.00 12.6 -13.7 172.
                                                  6.2
                                                       312.
41 26
      1
           1
              0.0 0.00 0.00
                              0.00 14.4 -6.0 272.
                                                  7.5
                                                       156.
42 27
                                   2.6 0.9 213.
      1
           1
              0.0 0.00 0.00
                              0.00
                                                  5.7
                                                       176.
43 28
      1
           1
              4.2 1.19 0.00
                              1.01 15.2 -15.3 173.
                                                   7.7
                                                       170.
44 29
              10.6 1.73 0.05
                              1.01 24.8 -3.5 302.
                                                   4.8
                                                       206.
45
   30
              3.5
                   1.92 0.29
                              4.81
                                    8.3 -5.9 280.
                                                   2.7
                                                       277.
46
   31
              0.0 0.00 0.00
                              0.00
                                   20.9
                                         2.3 228.
                                                   2.9
                                                       240.
47
              0.0
                   0.00 0.00
                              0.00
                                    7.5
                                         -4.9 241.
                                                   7.3
                                                       316.
48
              0.0
                  0.00 0.00
                              0.00
                                    7.6
                                        -4.6 316.
                                                   2.2
                                                       169.
49
              0.0 0.00 0.00
                              0.00
                                    3.6 -12.8 326.
                                                   4.3
                                                       322.
50
              0.0 0.00 0.00
                              0.00 13.0 1.1 307. 5.1
                                                       146. -18.0
51
```

Soil File

The default soil file name has an "ifc" extension (e.g., amarillo.ifc). This file contains the initial soil conditions at the start of a simulation run. The soil and management submodels then simulate the changes in these conditions as affected by weather, management, and erosion for each simulation day. Even intrinsic parameters such as particle size distribution will change with tillage as layers are mixed. If simulated soil parameters vary significantly from measured values, it is recommended that the user use the stand alone Erosion model (described below). The soil input file includes the taxonomic order, number and thickness (mm) of soil layers, detailed particle size distribution (fraction), wet and dry bulk density (Mg m⁻³), aggregate stability (ln(J m⁻²)), density (Mg m⁻³), and size distribution (fraction), soil crust properties (varies), random and oriented (ridge) roughness (mm), soil water characterization parameters (varies), dry albedo (fraction), organic matter (fraction), pH, calcium carbonate (fraction), and cation exchange capacity (meq 100g⁻¹). This file also contains comments (indicated by a '#' in column one) which describes each line of input data to aid in checking and modifying input data. Below is a description of the items required by WEPS which can be viewed and edited within soil panel of the WEPS interface. The absolute range is that allowable by WEPS. The typical range lists the range of values to be expected with typical soils. An example Soil file is shown in Figure 5.22.

The soil interface is a simple way to edit input data in the Soil file and is recommended. It is also recommended that the user select an existing soil file from the database with similar properties to the desired soil and modify its properties. Existing soil database files are accessed through the "Template" icon and the soil interface is accessed by clicking the "Soil" button at the bottom of the main screen. The information below is presented for the benefit of those users who wish to modify the input file themselves.

Soil File Parameters:

Version:

A version number to allow the user to choose between older ifc file format and the newer format which is Version 1.0 (described here). Contact WERU if you have ifc files in an older format that you want to use with WEPS.

Soil Identification

State - The state in which the soil occurs (character). The state is not critical to the operation of WEPS and is used for identification purposes only.

Estimated by: "Unknown"

County - The county in which the soil occurs (character). The county is not critical to the operation of WEPS and is used for identification purposes only.

Estimated by: "Unknown"

Soil Survey Area Name - The soil survey area name in which the soil occurs (character). The soil survey area name is not critical to the operation of WEPS and is used for identification purposes only.

Estimated by: "Unknown"

Soil Survey Area ID - The soil survey area identification for the soil (character). The soil survey area identification is not critical to the operation of WEPS and is used for identification purposes only.

Estimated by: "Unknown"

Map Unit Symbol - The symbol used to uniquely identify the soil map unit in the soil survey (character). The map unit symbol is not critical to the operation of WEPS and is used for identification purposes only.

Estimated by: "Unknown"

Surface Texture Class - The class of the surface layer based on USDA system for particle size (character). The texture class is not critical to the operation of WEPS and is used for identification purposes only.

Estimated by: "Unknown"

Component Name - The name of the soil (character). The soil component name is not critical to the operation of WEPS and is used for identification purposes only.

Estimated by: "Unknown"

Component Percent - The percentage of the soil component of the map unit (integer). The soil component percent is not critical to the operation of WEPS and is used for identification purposes only.

Absolute range = >0 to 100 Typical range = >0 to 100

Estimated by: "Unknown"

Local Phase - Phase criterion to be used at the local level to help identify soil components (character). The local phase is not critical to the operation of WEPS and is used for identification purposes only.

Estimated by: "Unknown"

Soil Taxonomic Order - The taxonomic soil order is the name for the highest level in soil taxonomy (character). The taxonomic soil order is not critical to the operation of WEPS and is used for identification purposes only.

Estimated by: "Unknown"

Soil Loss Tolerance (T factor) - The maximum amount of erosion at which the quality of a soil as a medium for plant growth can be maintained. (Tons/acre/year) The soil loss tolerance

is not critical to the operation of WEPS and is used for identification purposes only.

Absolute range = 1 - 5

Typical range = 1 - 5

Estimated by: "Unknown"

Slope Gradient - The difference in elevation between two points, expressed as a fraction of the distance between those points. (real fraction)

Absolute range = 0.0 - 0.999

Typical range = 0.0 - 0.3

Estimated by: slope = 0.01

Soil Surface Properties

Surface Fragment Cover - The fraction of the surface area covered by rock greater than 2.0 mm (m3/m3).

Absolute range = 0.0 to 1.0

Typical range = 0.0 - 0.5

Estimated by: Surface layer fragment volume

Depth to Bedrock - The observed depth to the top of the bedrock layer if present (mm).

Absolute range = 0.0 to 99990.0

Typical range =?

Estimated by: depth to bedrock = 99990.0

Soil Crust

Soil Crust Thickness - Average thickness of the consolidated zone in the surface layer (mm).

Absolute range = 0.0 to 23.0

Typical range = 0.0 to 10.0

Estimated by: crust thickness = 0.01

Soil Crust Density - The density of the soil crust (Mg/m^3).

Absolute range = 0.6 to 2.0

Typical range = 0.8 to 1.6

Estimated by: aggregate density

Soil Crust Stability - Mean of natural log of crust crushing energies (ln(J/kg))

Absolute range = 0.1 to 7.0

Typical range = 0.3 to 5.0

Estimated by: aggregate stability

Soil Crust Fraction - Fraction of surface covered with consolidated soil as opposed to aggregated soil (m^2/m^2).

Absolute range = 0.0 to 1.0

Typical range = 0.0 to 1.0

Estimated by: 0.0

Loose Material on Crust

Loose Material on Crust: Mass - Loose, saltation-size soil on the surface soil crusted area (kg/m^2).

Absolute range = 0.0 to 2.0

Typical range = 0.0 to 1.0

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Estimated by: 0.0

Loose Material on Crust: Fraction - Fraction of total soil surface area covered with loose material on the crust (m^2/m^2) .

Absolute range = 0.0 to soil crust fraction. Typical range = 0.0 to 0.5

Estimated by: 0.0

Roughness

Random Roughness - The standard deviation of heights of a random soil surface including any flat biomass adjusted as suggested by Allmaras (1966) (mm).

Absolute range = 1.0 to 30.0

Typical range = 2.0 to 10.0

Estimated by: 4.0

Ridge Orientation - Direction of the tillage ridge, clockwise from true north (degrees).

Absolute range = 0.0 to 179.99

Typical range = 0.0 to 179.99

Estimated by: 0.0

Ridge Height - The height of soil ridges from bottom of furrow to top of ridge (mm).

Absolute range = 0.0 to 500.

Typical range = 0.0 to 300.0

Estimated by: 0.0

Roughness Spacing - Spacing between ridge tops (mm).

Absolute range = 10.0 to 2000.0 Typ

Typical range = 60.0 to 1000.0

Estimated by: 0.0

Ridge Width - Width of the top of the ridge (i.e. bed width) (mm)

Absolute range = 10.0 to 4000.0

Typical range = 100.0 to 2000.0

Estimated by: 0.0

Soil Albedo Dry - The estimated ratio of the incident short-wave (solar) radiation that is reflected by the air dry, less than 2 mm fraction of the soil surface (unitless).

Absolute range = 0.00 to 1.00

Typical range = 0.05 to 0.25

Estimated by: method of method of Post et.al. (2000) or Baumer (1990).

Soil Layer Properties

Thickness - The thickness of each soil layer (mm). WEPS requires a specific layer structure which is determined by the soil interface.

Estimated by: user defined (required)

Sand - Mineral particles 0.05 to 2.0 mm in equivalent diameter as a weight fraction of the less than 2.0 mm fraction (kg/kg).

Absolute range = (>0.0) to 1.0

Typical range = [1.0 - (silt + clay)]

Estimated by: sand = 1.0 - (silt + clay)

Silt - Mineral particles 0.002 to 0.05 mm in equivalent diameter as a weight fraction of the less than 2.0 mm fraction (kg/kg).

Absolute range = (>0.0) to 1.0 Typical range = [1.0 - (sand + clay)]Estimated by: silt = 1.0 - (sand + clay)

Clay - Mineral particles less than 0.002 mm in equivalent diameter as a weight fraction of the less than 2.0 mm fraction (kg/kg).

Absolute range = (>0.0) to 1.0 Typical range = [1.0 - (sand + silt)]Estimated by: clay = 1.0 - (silt + sand)

Rock Fragments - The volume fraction of rock greater than 2.0 mm (m3/m3).

Absolute range = 0.0 to 1.0 Typical range = 0.0 - 0.5 Estimated by: rock fragments = 0.0

Estimated by: rock fragments = 0

Sand Fractions

Sand Fractions: Coarse - Mineral particles 0.5 to 1.0 mm in equivalent diameter as a weight fraction of the less than 2 mm fraction (kg/kg).

Absolute range = 0.0 to 1.0 Typical range = 0.0 to 1.0 Estimated by: CS = 0.0

Sand Fractions: Medium - Mineral particles 0.2 to 0.5 mm in equivalent diameter as a weight fraction of the less than 2 mm fraction (kg/kg).

Absolute range = 0.0 to 1.0 Typical range = 0.0 to 1.0

Estimated by: MS = 0.0

Sand Fractions: Fine - Mineral particles 0.1 to 0.2 mm in equivalent diameter as a weight fraction of the less than 2 mm fraction (kg/kg).

Absolute range = 0.0 to 1.0 Typical range = 0.0 to 1.0

Estimated by: FS = 0.0

Sand Fractions: Very Fine - Mineral particles 0.05 to 0.1 mm in equivalent diameter as a weight fraction of the less than 2 mm fraction (kg/kg).

Absolute range = 0.0 to 1.0 Typical range = 0.0 to 1.0

Estimated by: user defined (required)

Bulk Density

Bulk Density Dry - The oven dry weight of the less than 2 mm soil material per unit volume of soil exclusive of desication cracks, measured on a coated clod (Mg/m³).

Absolute range = (>0.0) to 10.0 Typical range = 0.8 to 1.6

Estimated by: Rawls (1983)

```
bulk density = 2.0 for layer depth > 300 mm
bulk density = 2.01 * (0.72 + .00092* layer depth) for layer depth < 300 mm
```

Bulk Density 1/3 Bar - The oven dry weight of the less than 2 mm soil material per unit volume of soil at a tension of 1/3 bar (Mg/m 3).

```
Absolute range = (>0.0) to 10.0 Typical range = 0.8 to 1.6 Estimated by: user defined (required)
```

Aggregate

Aggregate GMD - Soil aggregate geometric mean diameter of the modified log-normal distribution (mm).

```
Absolute range = 0.03 to 30.0 Typical range = 0.1 to 15.0 Estimated by: aggr. gmd = \exp(1.343 - 2.235 * \text{sand} - 1.226 * \text{silt} - 0.0238 * \text{sand/clay} + <math>33.6 * \text{om} + 6.85 * \text{CaCO}_3) * (1.0 + 0.006 * \text{layer depth})
```

Aggregate GSD - Soil aggregate geometric standard deviation of the modified log-normal distribution (dimensionless).

```
Absolute range = 1.0 to 40.0 Typical range = 4.0 to 15.0 Estimated by: aggr. gsd = 1.0 + 1.0 / (0.012448 + 0.002463(aggr. gmd) + 0.093467 / (aggr. gmd)^{0.5})
```

Aggregate Max. Size - Upper limit of the modified log-normal aggregate size distribution (mm).

```
Absolute range = 1.0 to 1000.0 Typical range = 2.0 to 100.0 Estimated by: aggr.max. size = (aggr. gsd)^p * (aggr. gmd) +0.84 where p = 1.52 (aggr. gsd)^{-0.35}
```

Aggregate Min. Size - Lower limit of the modified log-normal aggregate size distribution (mm).

```
Absolute range = 0.001 to 5.0 Typical range = 0.006 to 0.020 Estimated by: aggr min. size = 0.01
```

Aggregate Density - The aggregate density for (Mg/m³).

```
Absolute range = 0.6 to 2.5 Typical range = 0.8 to 2.0 Estimated by: Rawls (1983)
aggr density = 2.0 for layer depth > 300 mm
aggr density = 2.01 * (0.72 + 0.00092 * layer depth) for layer depth < 300 mm
```

Aggregate Stability - Mean of natural log of aggregate crushing energies (ln(J/kg))

```
Absolute range = 0.1 to 7.0 Typical range = 0.5 to 5.0 Estimated by: aggr. stability = 0.83 + 15.7 * \text{clay} - 23.8 * \text{clay}^2
```

Water Content

Water Content: Initial - Soil water content at the beginning of the simulation (cm³/cm³).

Typical range = varies with soil texture Absolute range = 0.0 to ??

Estimated by: ½ (field capacity + wilting point)

Water Content: Saturation - Soil water content when soil pores are completely filled (i.e. zero soil matric potential) (cm³/cm³).

Absolute range = 0.0 to ?? Typical range = varies with soil texture

Estimated by: Saxton, et al., (1986)

Note: Saturated water content > Field capacity water content > Wilting point water content

Water Content: Field Capacity (1/3 bar) - The amount of soil water retained at 1/3 bar (33 kPa), expressed as a fraction of the less than 2 mm, oven dry soil by volume (cm³/cm³).

Absolute range = 0.0 to ?? Typical range = varies with soil texture

Estimated by: Saxton, et al., (1986)

Note: Saturated water content > Field capacity water content > Wilting point water content

Water Content: Wilting Point (15 bar) - The amount of soil water retained at 15 bars (1500 kPa), expressed as a percentage of the less than 2 mm, oven-dry soil by volume (cm³/cm³).

Typical range = varies with soil texture Absolute range = 0.0 to ??

Estimated by: Saxton, et al., (1986)

Note: Saturated water content > Field capacity water content > Wilting point water content

CB - The power of Campbell's model of the soil water characteristics curve (unitless).

Absolute range = 0.917 to 27.027Typical range = varies with soil texture Estimated by: Saxton, et al., (1986)

Air Entry Pot. - The air entry potential is defined as the potential at which the largest water-filled pores start to drain and hence gas flow can be observed (Joules/kg).

Absolute range = -17.91 to 0.0Typical range = varies with soil texture Estimated by: Saxton, et al., (1986)

Sat. Hydraulic Conductivity - The amount of water that would move vertically through a unit area of saturated soil in a unit time under unit hydraulic gradient (m/s).

Absolute range = 0.0 to 1E-3 Typical range = 0.0 to 1E-3

Estimated by: Saxton, et al., (1986)

Other Layer Properties

Organic Matter - The amount by weight of decomposed plant and animal residue expressed

as a weight fraction of the less than 2 mm soil material (kg/kg).

Absolute range = 0.0 to 1.0 Typical range = 0.0005 to 0.05

Estimated by: user defined (required)

pH - The negative logarithm to the base 10, of the hydrogen ion activity in the soil using 1:1 soil:water ratio method (unitless). A numerical expression of the relative acidity or alkalinity of a soil sample.

Absolute range = 1.0 to 14.0

Typical range = 4.0 to 9.0

Estimated by: pH = 7.0

CaCO3 - The quantity of carbonate (CO3) in the soil expressed as CaCO3 and as a weight percentage of the less than 2 mm size fraction (kg/kg).

Absolute range = 0.0 to 1.0

Typical range = 0.0 to 0.3

Estimated by: user defined (required)

CEC - The cation exchange capacity (meq/100g).

Absolute range = 0.0 to 400.0

Typical range = 0 to 400.0

Estimated by: user defined (required)

Linear Extensibility Percent - The linear expression of the volume difference of natural soil fabric at 1/3 or 1/10 bar water content and oven dryness. (m $^3/m^3$)

Absolute range = 0.0 to 0.3

Typical range =?

Estimated by: Soil Survey Staff (1996).

Figure 5.21. Example Soil File.

```
#Soil ID
```

KS181-KUU-Kuma-100-SIL-Kansas-Sherman County-Sherman County, Kansas

Local Phase

N/A

Taxorder

Mollisols

number of soil layers

3

Layer thickness (mm)

130 610 780

Sand fraction

 $0.113 \quad 0.073 \quad 0.114$

Silt fraction

0.677 0.662 0.686

Clay fraction

0.210 0.265 0.200

Rock fragments

0.020 0.020 0.040

Sand fraction coarse

```
0.000 \quad 0.000 \quad 0.000
# Sand fraction medium
0.009 0.007 0.009
# Sand fraction fine
0.033 0.022 0.034
# Sand fraction very fine
0.066 0.038 0.066
# Water dispersible clay
0.000 \quad 0.000 \quad 0.000
# Bulk Density (dry)
1.310 1.490 1.520
# Bulk Density (1/3 bar)
1.250 1.300 1.450
# Aggregate geometric mean diameter for layer
0.030 17.562 26.157
# Aggregate geometric standard deviation for layer
1.000 13.917 11.730
# Maximum aggregate size for layer
1.000 53.043 62.079
# Minimum aggregate size for layer
0.010 \quad 0.010 \quad 0.010
# Aggregate density for layer
1.688 2.000 2.000
# Aggregate stability for layer
3.077 3.319 3.018
# Soil crust thickness (mm)
0.010
# Soil crust density
1.688
# Soil crust stability
3.08
# Soil crust surface fraction
0.00
# Loose material on crust (kg)
0.00
# Fraction of loose material on crust
0.00
# Random roughness
4.00
# Ridge orientation
0.00
# Ridge height
0.00
# Spacing between ridge tops
0.00
# Ridge width
0.00
# Initial soil water content for layer
0.212 0.228 0.197
# Saturation soil water content for layer
0.394 0.391 0.338
# Field capacity water content for layer
0.286 \quad 0.300 \quad 0.273
# Wilting point water content for layer
```

0.138 0.157 0.121

```
# Soil CB value for layer
4.212 4.748 4.119
# Air entry potential for layer
-4.544 -4.224 -4.686
# Saturated hydraulic conductivity for layer
9.0E-6 9.0E-6 9.0E-6
# curve number---good
0.00
# curve number---poor
# Dry soil albedo
0.230
# Organic matter for layer
0.030 0.018 0.005
# Soil PH for layer
7.30 7.50 8.50
# Calcium carbonate equivalent for layer(CaCO3)
0.50 0.03 0.08
# Cation exchange capacity for layer
12.50 15.00
              11.50
# Sum of bases for layer
0.00 0.00 0.00
# Electrical Conductivity
0.00 0.00 0.00
# Sodium Adsorption Ratio
0.00 0.00 0.00
# Available nitrogen for layer
0.00 0.00 0.00
# Available phosphorus for layer
0.00 0.00 0.00
```

Management File

The default file name is '*.man'. This file contains parameters for the manipulation of soil and biomass properties as a result of various management operations performed on the field on a given date. These operations include planting, harvesting, cultivation, defoliation, fertilization, and irrigation. The management file should only be altered using the Management Crop Rotation Editor for WEPS (MCREW) to guarantee that parameters are correct. MCREW is accessed through the WEPS user interface.

Stand Alone Erosion Submodel

The Erosion submodel (tsterode) can also be operated as a stand alone model to simulate erosion for a single storm (i.e., daily). Input parameters which must be provided for the day include the field and barrier dimensions as well as biomass, soil, hydrology, and weather parameters. Wind speed can be entered either as Weibull distribution parameters or listed as average wind speeds for each time period throughout the day. The input file contains comments (indicated by a '#' in column one) which describes each line of input data to aid in checking and modifying input data. Specific definitions of these parameters are

documented within the input file (Fig. 5.22).

Command Line Options

Usage: tsterode -i"input_filename" <"input_filename" >"output_filename" -x#
-v# -t# -u -E -Plot -?

Valid command line options:

-? or -h

Display the available command line options.

-x#

Number of grid points in x direction (min. = 3; max. = 500). The submodel calculates the loss/deposition over a series of individual, equal sized grid cells representing the entire simulation region. The more grid points, the smaller the area in each grid cell. The recommended total number of grid cells is 30 for a field without a barrier and 60 for a field with a barrier. Increasing the number of grid cells, increases the accuracy of the soil loss/deposition estimates as well as increases the run time. If not specified, th number of grid points is calculated within the model.

-y#

Number of grid points in x direction (min. = 3; max. = 500). The submodel calculates the loss/deposition over a series of individual, equal sized grid cells representing the entire simulation region. The more grid points, the smaller the area in each grid cell. The recommended total number of grid cells is 30 for a field without a barrier and 60 for a field with a barrier. Increasing the number of grid cells, increases the accuracy of the soil loss/deposition estimates as well as increases the run time. If not specified, th number of grid points is calculated within the model.

-t#

Interval for surface updating in seconds (min. = 60 seconds; max. = 86400 seconds). This is used to specify a fixed surface updating interval and is primarily for testing and evaluation purposes. Since the erosion code contains an update loop dependent upon the number of time intervals/day and an inner loop that allows more frequent surface updating to occur, the imp interval must be evenly divisible into both the number of time intervals/day and 24 (hours in a day). If these conditions are not met the program aborts with an error message.

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-u Disable erosion surface updating.

-i"input_filename" Specify input filename (must use prior to -E option).

<"input filename" Specify input filename.

>"output filename" Specify output filename (default is to print to screen).

-E Erosion summary (kg/m^2) (positive values are soil loss). The output in the file contains the following:

Total salt/creep susp PM10 input filename

The "-E' option requires that the input file (-i"input_filename") be specified as a commandline argument prior to the "-E" option, e.g.:

tsterode -i input filename.ext -E

The "input_filename" in the erosion summary is the same name as the input_filename with a ".ero" extension and will be created in the same directory specified for the input_filename.

-Plot Enable printing of file which can be used to plot various data.

Default options are set to: -t900

Note that these command line options cannot be specified when the erosion submodel is run through the WEPS interface.

Figure 5.22. Example stand alone erosion input file.

```
EROSION initialization flag
.TRUE.
#
      EROSION "print" flag
1
 +++ SIMULATION REGION +++
#
#
      Simulation region diagonal coordinates (meters)
#
       specify in this form: x1,y1 x2,y2
0.0,
      0.0 180.0, 180.0
#
      Simulation region orientation angle (degrees from North)
0.0
#
      Number of accounting regions (must be 1)
1
 +++ ACCOUNTING REGIONS +++
#
      Accounting region diagonal coordinates (meters)
       specify in this form: x1,y1 x2,y2
0.0, 0.0 180.0, 180.0
# +++ BARRIERS +++
#
#
      Number of barriers (0-5)
0
#
      Barrier diagonal coordinates (meters)
#
       specify in this form: x1,y1 x2,y2
 0.0, 0.0 0.0 100.0
#
      Barrier height (meters), porosity (m2/m2), width (meters)
 1.2 0.50 2.0
      Repeat the above two input lines for each barrier
# +++ SUBREGION REGIONS +++
#
#
      Number of subregions (must be 1)
1
      Subregion diagonal coordinates (meters)
       specify in this form: x1,y1 x2,y2
#
0.0, 0.0 180.0, 180.0
#
 +++ BIOMASS +++
#
#
      Height of standing biomass (meters)
0.0
#
      Stem area index (m2/m2), leaf area index (m2/m2)
       both refer to STANDING biomass only
0.0 0.0
    Crop row spacing (meters), 0.0=broadcast; plant location (0=furrow,1=ridge)
0.0, 0
      Flat biomass cover (m2/m2)
0.04
 +++ SOIL +++
#
#
      Number of soil layers (3-10)
#
3
#
      The following soil inputs are repeated for each layer
#
      layer thickness (mm)
#
      40.0 200.0
10.0
      bulk density (g/cm3)
```

```
1.4 1.4
1.4
      sand content, 0.05-2.0 \text{ mm} \text{ (kg/kg)}
0.83 0.83 0.83
     very fine sand, 0.05-0.1 \text{ mm (kg/kg)} 0.20 \ 0.20
#
0.20
      silt content (kg/kg)
0.09 0.09 0.09
      clay content (kg/kg)
0.08 0.08 0.08
#
      rock volume (m3/m3)
0.0
      0.0 0.0
#
      aggregate density (g/cm3)
1.8
      1.8 1.8
      aggregate stability (ln[J/kg])
#
1.93
      2.65 2.65
      The next 4 parameters define the aggregate size
        distribution for each layer.
        aggregate geometric mean diameter (mm)
0.28 0.98 0.98
#
       minimum aggregate size (mm)
0.001 0.01 0.01
#
       maximum aggregate size (mm)
14.9 48.8 48.8
        aggregate geometric standard deviation (mm/mm)
25.4
     20.4 20.4
      The next six variableas are surface crust variables
        for each layer.
        fraction of soil surface that is crusted (m2/m2)
        crust (consolidated zone) thickness (mm)
        fraction of crusted surface covered by loose material (m2/m2)
#
        mass of loose material on crusted surface (kg/m2)
        crust density (g/cm3)
        crust stability (ln[J/kg])
      3.51 0.29 0.255
0.5
                        1.2
#
      Allmaras random roughness (mm)
1.7
      The next four variables are ridge variables for each layer.
#
       Ridge height (mm)
       Ridge spacing (mm)
       Ridge width (mm)
       Ridge orientation (degrees from North)
20.0
      1016.0
              0.0
                    90.0
      Dike spacing (mm)
0.0
#
      Snow depth (mm)
0.0
#
# +++ SOIL WATER +++
      Soil layer wilting point water content (kg/kg)
0.05 0.05 0.05
      Soil layer water content (kg/kg)
0.01 0.05 0.05
      HOURLY soil water content at soil surface (kg/kg)
       two lines, with 12 values on each line
+++ WEATHER +++
      Air density (g/cm3)
```

```
1.2
       Wind direction (deg)
286.0
       Number of intervals/day, maximum = 96
#
48
#
       Information about the anemometer
       anemometer height (meters)
       aerodynamic roughness at anemometer site (mm)
       anemometer location flag (0 - away from field, 1 - on field)
#
2.0
       Wind/Weibull flag (0 -use Weibull parameters, 1 -use wind speeds)
#
0
#
      Wind statistics. These parameters are used only when the Wind/Weibull flag
= 0
        Fraction of time that winds are calm (hr/hr)
        Weibull "c" factor (m/s)
#
       Weibull "k" factor
#
0.217
       7.125 2.971
#
      Wind speeds (m/s). The wind data are used only when the Wind/Weibull flag
= 1
        Must have as many wind speeds as number of intervals/day.
       Must have 6 values per line.
#
       Wind data should be AVERAGES for the period.
#
       Hourly averages will likely underestimate wind erosion somewhat.
#
       30-min averages or shorter is more suitable (As is done here).
     0.00
             0.00
#
                     0.00
                             0.00
                                     0.00
                                             1.19
                                              5.20
#
     2.76
             3.47
                     4.00
                             4.44
                                     4.84
     5.54
             5.87
                    6.20
                            6.53
                                     6.86
                                             7.20
    7.56
            7.95
                   8.39
                             8.91
                                     9.57
                                            10.64
    11.86
          10.02
                    9.21
                            8.64
                                     8.16
                                             7.75
     7.38
                                     6.04
#
            7.03
                    6.69
                            6.36
                                             5.71
#
     5.37
             5.02
                     4.64
                             4.23
                                     3.75
                                             3.15
                  0.00
     2.24
            0.00
                            0.00
                                     0.00
                                             0.00
 +++ VARIABLES TO WRITE TO 'PLOT.OUT' +++
       Flag for writing variables to 'plot.out'.
#
        -1 = write nothing
        0 = write erosion variables;
       Write variables below if flagged with a 1
0
#
      Next are 2 lines per variable:
       1st line: flag (0=don't write, 1=do write) and variable description
#
        2nd line: this info is used as a header in 'plot.out'
#
            place header within first 12 positions of the line
#
#
      Field length (m)
0
   length(m)
      biomass height (m)
1
   bio ht(m)
      Stem area index (m2/m2)
1
    stem area
#
      Biomass leaf area index (m2/m2)
1
```

#

0

lai area

Biomass flat fraction cover (m2/m2)

```
flat cov
#
       Soil fraction very fine sand in layer 1 (kg/kg)
0
#
       Soil fraction sand in layer 1 (kg/kg)
0
#
      Soil fraction silt in layer 1 (kg/kg)
0
#
      Soil fraction clay in layer 1 (kg/kg)
0
    clay
#
      Soil volume rock in layer 1(m3/m3)
0
   rock vol
#
      Soil aggregate stability (ln[J/kg])
0
    ag stab
#
      Aggregate geometric mean diameter (mm)
0
   ag_gmd
#
      Minimum aggregate size (mm)
0
   ag_min
#
      Maximum aggregate size (mm)
0
   ag_max
      0
   ag_std
#
      Fraction of soil surface that is crusted (m2/m2)
0
   crust cv
#
      Crust (consolidated zone) thickness (mm)
0
  crust z (mm)
       Faction of crusted surface covered by loose material (m2/m2)
0
#
      Mss of loose material on crusted surface (kg/m2)
0
  los(kg/m2)
      Crust density (g/cm3)
0
   cr den
#
      _Crust stability (ln[J/kg])
0
#
      _Allmaras random roughness (mm)
0
   rr(mm)
#
      Ridge height (mm)
0
  z_rgh(mm)
      Ridge spacing (mm)
0
  x rgs(mm)
      Ridge width (mm)
  x rgw(mm)
```

```
# Ridge orientation (degrees from North)
0
a_rgo(deg)
```

Figure 5.23 is an example standalone erosion submodel output file. It contains a listing of the inputs to the submodel followed by the generated results labeled 'OUTPUT FROM ERODOUT.FOR'. This section lists the amount of total, suspension, and PM10 leaving each boundary and field grid cell. At the bottom of the file is the filed average of each of these grid cells.

Figure 5.23. Example stand alone erosion output file.

```
REPORT OF INPUTS (read by erodin.for)
+++ Control Flags, etc. +++
ntstep am0eif nsubr nacctr nbr am0efl
+++ SIMULATION REGION +++
orientation and dimensions of sim region
amasim(deg) amxsim - (x1,y1) (x2,y2) 0.00 0.00 0.00 276.00 276.00
+++ ACCOUNTING REGIONS +++
nacctr - number of accounting regions
accounting region dimensions (x1,y1) (x2,y2)
                  0.00 276.00 276.00
      0.00
+++ BARRIERS +++
 no barriers
+++ SUBREGIONS +++
nsubr - number of subregions
****************** Subregion 1 *************
+++ BIOMASS +++
Biomass ht, SAI, LAI, flat cover 0.000 0.000 0.000 0.000
+++ SOTI +++
nslay - number of soil layers

        layer depth b.density vfsand
        sand
        silt
        clay
        rock vol

        1 230.00
        1.05
        0.14
        0.22
        0.71
        0.08
        0.00

        2 680.00
        1.05
        0.14
        0.22
        0.71
        0.08
        0.00

        3 610.00
        1.05
        0.14
        0.22
        0.71
        0.08
        0.00

        x
        AgD
        AgS
        GMD
        GMDmn
        GMDmx
        GSD

        1.87
        1.00
        1.64
        0.01
        36.73
        15.13

        2.00
        1.87
        7.68
        0.01
        41.79
        16.17

        2.00
        1.87
        30.00
        0.01
        70.96
        9.98

laver
Cr frac mass LOS frac.LOS, density stability
      0.00 0.00 0.00 1.87
```

```
Rg ht, width, spacing, orient., dike spacing
              0.00 0.00 0.00 0.00 0.00
+++ HYDROLOGY +++
Snow depth (mm)
0.0000000E+00
layer wilting and actual water contents
         0.05 0.02
0.05 0.02
         0.05
                    0.02
Hourly water contents - ahrwc0
            0.02 0.02
                                       0.02
                                                  0.02
                                                              0.02
     0.02
     0.02
                0.02
                          0.02
                                       0.02
                                                   0.02
                                                              0.02
                0.02
                            0.02
                                       0.02
                                                   0.02
                                                              0.02
     0.02
              0.02
                        0.02 0.02
     0.02
                                                  0.02
                                                              0.02
+++ WEATHER +++
 anemht
              awwzo wzoflg
2.00000000 25.0000000 1
 wind dir (deg) and max wind speed (m/s)
  250.00 11.86
Wind speeds (m/s) - 48 intervals 0.00 \ 0.00 \ 0.00 \ 0.00
                                                   0.00
     2.76
                3.47
                           4.00
                                       4.44
                                                   4.84
                5.87
                          6.20
     5.54
                                       6.53
                                                   6.86
                                                             7.20
     7.56
                7.95
                            8.39
                                       8.91
                                                   9.57
                                                            10.64
    11.86
              10.02
                           9.21
                                       8.64
                                                   8.16
                7.03
                           6.69
     7.38
                                       6.36
                                                   6.04
                                                              5.71
     5.37
                5.02
                          4.64
                                    4.23
                                                  3.75
                          0.00
     2.24
                0.00
                                                  0.00
END OF INPUTS
OUTPUT FROM ERODOUT.FOR
Passing Border Grid Cells - Total
                                                    egt (kg/m)
  \texttt{top}(\texttt{i}=\texttt{1},\texttt{imax}-1,\texttt{j}=\texttt{jmax}) \ \texttt{bottom}(\texttt{i}=\texttt{1},\texttt{imax}-1,\texttt{j}=\texttt{0}) \ \texttt{right}(\texttt{i}=\texttt{imax},\texttt{j}=\texttt{1},\texttt{jmax}-1) \ \texttt{left}(\texttt{i}=\texttt{0},\ \texttt{j}=\texttt{1},\texttt{jmax}-1)
        3.58 5.51 7.90 10.63 13.56 16.56 19.55
5.87 27.36 27.64 27.79 27.88 27.92 27.95
98 27.98 27.98 27.98 27.98 27.98
                                                                                                                       19.55
   24.57 Zo..
27.98
 27.97
       0.00 0.00
                                                                                         0.00
0.00
0.00
76.8
                  0.00 0.00
     0.00
  0.00

    13.93
    37.80
    59.60
    70.80
    74.85
    76.21
    76.66
    76.81
    76.86

    6.88
    76.88
    76.88
    76.88
    76.88
    76.88
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    76.88
    76.88
    76.88
    76.88
    76.88
    76.88
    76.88
    76.88
    7
   76.88
 76.88
       0.00
     0.00
                                                                                                                                    0.00
  0.00
  Passing Border Grid Cells - Suspension
                                                              egtss (kg/m)
   top (i=1,imax-1, j=jmax) bottom (i=1,imax-1, j=0) right (i=imax, j=1,jmax-1) left (i=0,
j=1,jmax-1)

    0.72
    1.65
    3.09
    5.03
    7.52
    10.57
    14.18
    18

    33.59
    39.21
    44.95
    50.76
    56.59
    62.45
    68.32
    74.2

    91.85
    97.73
    103.61
    109.50
    115.38
    121.26
    127.15
    133.03

       0.21
   28.15 33...
28.15 91.85
0.
                                                                                                                   74.20
 85.96
       0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00
                   0.00 0.00
                                                             0.00 U.C
0.00 0.00
                                                                                                        0.00
  0.00
     0.00
  0.00
  Passing Border Grid Cells - PM10
                                                   egt10 (kg/m)
   top (i=1,imax-1, j=jmax) bottom (i=1,imax-1, j=0) right (i=imax, j=1,jmax-1) left (i=0,
j=1,jmax-1)
```

0.0046 0.0193 0.0473 0.0912 0.1488 0.2196 0.3027 0.3977 0.5039 0.7463 0.8784 1.0145 1.1531 1.2931 1.4338 1.5750 1.7164 1.8579	
2.1412 2.2828 2.4245 2.5662 2.7079 2.8496 2.9913 3.1329 3.2746 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000	
0.3050 0.9706 1.8304 2.7605 3.6919 4.5786 5.3937 6.1209 6.7510 7.7153 8.0603 8.3271 8.5281 8.6755 8.7810 8.8547 8.9051 8.9387	
8.9748 8.9836 8.9891 8.9924 8.9944 8.9956 8.9963 8.9966 8.9969 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000	
0.0000 0.00000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.00000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.00000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000	
$ \begin{array}{cccccccccccccccccccccccccccccccccccc$	-2.16 -1.70
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$ \begin{array}{cccccccccccccccccccccccccccccccccccc$	-2.16
-0.27 -0.51 -0.73 -0.97 -1.25 -1.51 -1.73 -1.91 -2.06	-2.16
$\begin{array}{cccccccccccccccccccccccccccccccccccc$	-1.70 -2.16
$\begin{array}{cccccccccccccccccccccccccccccccccccc$	-1.70
$\begin{array}{cccccccccccccccccccccccccccccccccccc$	-2.16 -1.70
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$ \begin{array}{cccccccccccccccccccccccccccccccccccc$	-2.16 -1.70
$\begin{array}{cccccccccccccccccccccccccccccccccccc$	-2.16 -1.70
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$\begin{array}{cccccccccccccccccccccccccccccccccccc$	-2.16 -1.70
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$ \begin{array}{cccccccccccccccccccccccccccccccccccc$	-2.16 -1.70
$ \begin{array}{cccccccccccccccccccccccccccccccccccc$	-2.16
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$\begin{array}{cccccccccccccccccccccccccccccccccccc$	-2.16
$\begin{array}{cccccccccccccccccccccccccccccccccccc$	-1.70 -2.16
$ \begin{array}{cccccccccccccccccccccccccccccccccccc$	-1.70
$\begin{array}{cccccccccccccccccccccccccccccccccccc$	-2.16 -1.70
$ \begin{array}{cccccccccccccccccccccccccccccccccccc$	-2.16 -1.70
$ \begin{array}{cccccccccccccccccccccccccccccccccccc$	-2.16 -1.70
$\begin{array}{cccccccccccccccccccccccccccccccccccc$	-2.15

3.00	AII	ENDIA .	7. USIIV	G WEI	5 WIIII	WIEASU	KED DE	11A	WEIS
-2.14 -1.70	-2.02 -1.70	-1.90 -1.70	-1.82 -1.70	-1.77 -1.70	-1.74 -1.70	-1.72 -1.70	-1.71 -1.70	-1.71 -1.70	-1.70
-0.27 -2.15	-0.51 -2.04	-0.73 -1.93	-0.97 -1.84	-1.24 -1.79	-1.49 -1.75	-1.70 -1.73	-1.88 -1.72	-2.03 -1.71	-2.14 -1.71
-2.16	-2.09	-1.97	-1.88	-1.82	-1.78	-1.75	-1.74	-1.73	-1.72
-2.16	-2.14	-2.05	-1.96	-1.89	-1.84	-1.80	-1.78	-1.77	-1.76
-2.10	-2.16	-2.15	-2.09	-2.02	-1.97	-1.92	-1.89	-1.87	-1.85
-1.98	-2.07	-2.13	-2.16	-2.17	-2.15	-2.13	-2.10	-2.08	-2.06
-1.79	-1.87	-1.94	-1.99	-2.04	-2.08	-2.11	-2.13	-2.15	-2.16
-1.45	-1.52	-1.57	-1.62	-1.66	-1.69	-1.72	-1.74	-1.76	-1.78
-0.20 -0.82 -0.91	-0.30 -0.84	-0.40 -0.86 -0.92	-0.50 -0.87 -0.92	-0.59 -0.88 -0.92	-0.65 -0.89 -0.92	-0.70 -0.90 -0.92	-0.74 -0.90 -0.92	-0.76 -0.91 -0.92	-0.79 -0.91
				****		***-	***-	***-	
Leaving :	Field Grid 0 15–0	Cells - Si	uspension _0 /1	egtss -0.56	(kg/m^2)	-0.88	-1 04	-1 20	-1 35
-1.48 -1.70	-1.57 -1.70	-1.62 -1.70	-1.66 -1.70	-1.68 -1.70	-1.69 -1.70	-1.69 -1.70	-1.69 -1.70	-1.70 -1.70	-1.35 -1.70
-0.06 -1.48 -1.70	-0.15 -1.57 -1.70	-0.27 -1.62 -1.70	-0.41 -1.66 -1.70	-0.56 -1.68 -1.70	-0.72 -1.69 -1.70	-0.88 -1.69 -1.70	-1.04 -1.69 -1.70	-1.20 -1.70 -1.70	-1.35 -1.70
-0.06 -1.48 -1.70	-0.15 -1.57 -1.70	-0.27 -1.62 -1.70	-0.41 -1.66 -1.70	-0.56 -1.68 -1.70	-0.72 -1.69 -1.70	-0.88 -1.69 -1.70	-1.04 -1.69 -1.70	-1.20 -1.70 -1.70	-1.35 -1.70
•		•	•	•	•	•	•	•	•
									•
•									
Leaving	Field Grid	Cells - PI	M10 egt	10 (kg/m^2	0 0204	0 0240	0 0274	0 0207	-0.0337
-0.0363	-0.0043	-0.0393	-0.0127	-0.0100	-0.0204	-0.0240	-0.0274	-0.0307	-0.0337
-0.0409	-0.0409	-0.0409	-0.0409	-0.0409	-0.0409	-0.0409	-0.0409	-0.0409	
-0.0013 -0.0363	-0.0043 -0.0381	-0.0081	-0.0127	-0.0166	-0.0204	-0.0240	-0.0274	-0.0307	-0.0337 -0.0409
-0.0409	-0.0409	-0.0409	-0.0409	-0.0409	-0.0409	-0.0409	-0.0409	-0.0409	
-0.0013	-0.0043	-0.0081	-0.0127	-0.0166	-0.0204	-0.0240	-0.0274	-0.0307	-0.0337
-0.0409	-0.0409	-0.0409	-0.0409	-0.0409	-0.0409	-0.0409	-0.0409	-0.0409	-0.0409
								•	
*********	Eiold								
**Averages Total		reep	susp	PM10					
egt		kg/m^2	egtss						
		34 -:							
**Averages Location	Total	Suspe	nsion	PM10					
ton	21 59	55.	45	1.39					
bottom right	0.00	0.	00	0.00					
right left	72.45			7.12					
Compari	sion of in	terior & b	oundary lo	SS					
inte	rior	boundary	Int/bnd	raulo					

APPENDIX 4: USING WEPS WITH MEASURED DATA WEPS

5.86

-120593.77 120593.91

-1.00

repeat of total, salt/creep, susp, PM10: 1.58 0.34 1.24 0.0308

References

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"HOW TO" GUIDES





Barriers

Wind barriers in WEPS include any structure designed to reduce the wind speed on the downwind side of the barrier. They also trap moving soil. Barriers include but are not limited to, linear plantings of single or multiple rows of trees, shrubs, or grasses established for wind erosion control, crop protection, and snow management. Snow fences, board walls, bamboo and willow fences, earthen banks, hand-inserted straw rows, and rock walls have also been used as barriers for wind erosion control in limited situations. Barriers also reduce evapotranspiration, shelter livestock, and provide wildlife habitat. One advantage of barriers over most other types of wind erosion control is they are relatively permanent. During drought years, barriers may be the only effective and persistent control measure on crop land. Barriers primarily alter the effect of the wind force on the soil surface by reducing wind speed on the downwind side of the barrier but also reduce wind speed to a lesser extent upwind of the barrier (Fig 6.1).

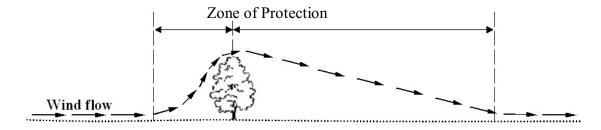


Figure 6.1. Diagram showing wind flow pattern over a barrier.

Research has shown that barriers significantly reduce wind speed downwind, sheltering a portion of the field from erosion and in effect, reducing the field length along the erosive wind direction. However, the protected zone of any barrier diminishes as porosity increases and is reduced significantly when barrier porosity exceed 60 percent. Protection is also reduced as wind velocity increases but the protected area diminishes as the wind direction deviates from the perpendicular to the barrier. Various types of barriers are used for wind erosion control in WEPS 1.0. The WEPS interface provides a method of selecting from a list of barriers to place on the field and editing the barrier properties. The user can also modify properties in the barrier database that appear in the drop down list. Each of these properties are described below.

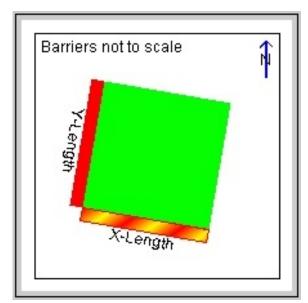


Figure 6.2. Field View Panel.

Wind Barrier Information N Shrubs w/o leaves(1 r... ▼ S none E none W none Edit Selected Barrier

Figure 6.3. Simulation Run Information Panel.

Adding and Removing Barriers Using the Interface

The Field View Panel (Fig. 6.2), located in the center of the WEPS1.0 main screen, is designed to give the user a view of the field size, shape, and orientation (green). The placement of any barriers present is displayed in red. Note that if the ratio of actual length to width of the field or barriers is too great to display to scale, this will be indicated within the panel and an approximation of the field or barrier shape will be displayed. This panel is for viewing only and is not editable.

The wind barrier panel (Fig. 6.3) is used to add barriers to the field. Note that WEPS1.0 only allows barriers on the borders of the field. The barrier location for each field border is labeled 'N' for north, 'S' for south, 'E' for east, and 'W' for west. The barrier type can be selected from the drop down list in the panel by clicking the down arrow to the right of the barrier type to bring up the list of available barriers and then clicking on the appropriate barrier. Once a barrier type is selected, the barrier properties may be viewed and edited by clicking the 'Edit Selected Barrier' button at the bottom of the panel. A separate panel opens where the user may change the default barrier

width, height, and porosity values in the appropriate fields. The modified barrier parameters are stored with the project. If a barrier other than 'None' is selected, the 'Edit Selected Barrier' button will open the properties panel only if the radio button is clicked on for that barrier. To remove a barrier from the field, click the radio button to select it (notice the barrier in the View Panel will be 'highlighted' when selected) then select the barrier type 'None', to remove it.

Edit Selected Barrier

To view and edit the properties of a barrier, click the radio button for the corresponding barrier , then click the 'Edit Selected Barrier' button. A window will open displaying the properties shown below. If properties are modified by the user through the interface, the barrier type will display '<mod>' in front of the barrier type name.

The length of a barrier is defined by the field length along the border on which the barrier is placed.

Width

The width of a barrier is defined as the distance from one side of the barrier

to the other, in the units of measure displayed on the screen (feet or meters) (Fig. 6.4). For a single row wind barrier, the width is equal to the diameter of the tree, shrub, or grass, or for artificial barriers, thickness of the material (e.g. slat fence). This is illustrated as "a" in Fig. 6.4. multiple row barriers, the width is the distance from one side of the barrier to the other as illustrated by "b" in Fig. 6.<u>4</u>.

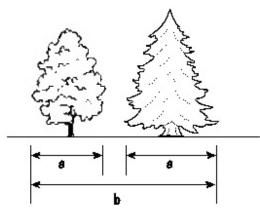


Figure 6.4. Barrier width for single (a) and multiple (b) row barriers.

Height

The height of a barrier is the average height of individual elements (e.g. trees)

in the barrier ("a" in Fig. $6.\underline{16}$, $\underline{5}$ for single row barriers). The units of measure for barrier height are displayed on the input screen in feet or meters. For multiple row barriers, use the height of the tallest barrier row ("b" in Fig. $6.\underline{16}$, $\underline{5}$).

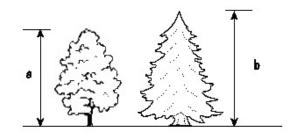


Figure 6.5. Barrier height for single (a) and multiple (b) row barriers.

Area

The area of the barrier is calculated from the barrier width and length (i.e., barrier width x field length). This is not an editable item, but is calculated within WEPS 1.0.

Porosity

Barrier porosity is defined as the total optical porosity of all rows in the barrier. It is the open space (i.e., absence of leaves and stems) as viewed looking perpendicular to the barrier, expressed as a percent of the total area (ie., (1.0 - silhouette area) x 100). WEPS 1.0 does not "grow" living barriers. They do not increase or decrease porosity with leaf growth and leaf drop (senescence), nor do they increase in size from one year to the next. As such, the porosity of barriers in WEPS does not change with the seasons nor from year to year. Therefore the user should input the porosity of the barrier that is present when the erosion hazard is the greatest. Figure 6.18, 6 illustrates the effect of porosity on the near surface wind speed relative to an open field without a barrier.

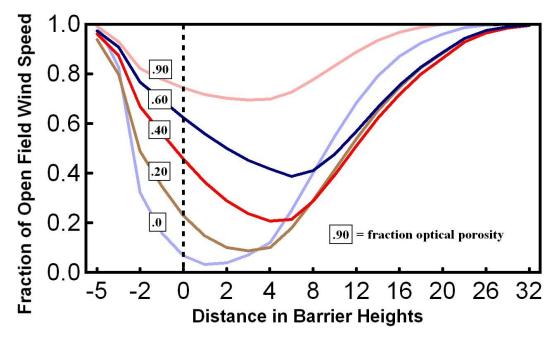


Figure 6.6. Effect of the fraction of optical porosity on near surface wind speed along the wind direction relative to barrier.

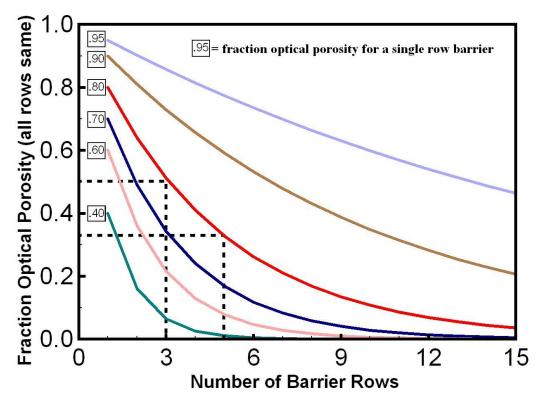


Figure 6.7. Effect of number of barrier rows on optical porosity where all barrier rows are the same.

At times, it is most efficient to estimate optical porosity for a single row, particularly for crop barriers. Then for multiple row barriers, the optical porosity decreases for the entire barrier as illustrated in Figure $6.\underline{7}$. For example, a single row of corn has an optical porosity of 0.80. Three rows of corn have an optical porosity of 0.50 while five rows of corn have an optical porosity of 0.33.

The following graphic illustrations (Figs 6.8 - 6.10) can be used as a guide to determine optical porosity for single row barriers in the field.

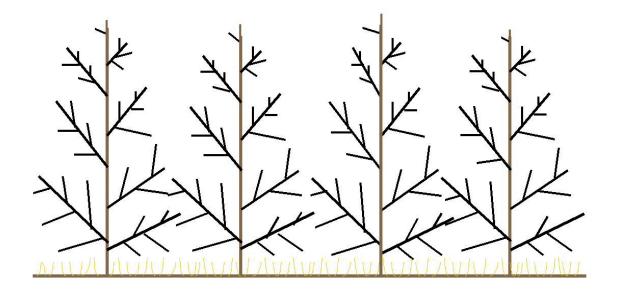


Figure 6.8. Graphic illustration of a barrier with an optical porosity of ?.??.

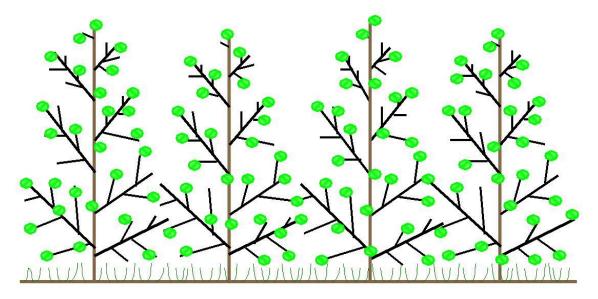


Figure 6.9. Graphic illustration of a barrier with an optical porosity of ?.??.

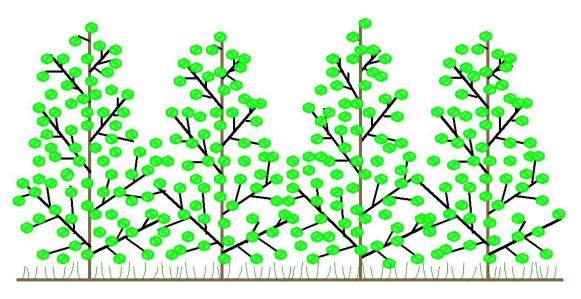


Figure 6.10. Graphic illustration of a barrier with an optical porosity of ?.??.

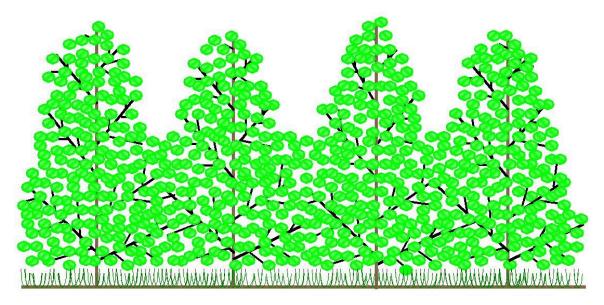


Figure 6.11. Graphic illustration of a barrier with an optical porosity of ?.??.

Barrier Property Database

Default barrier properties specified in the barrier property database cannot be permanently changed through the WEPS interface. But they can be modified and stored with the current project. Barrier properties may however, be modified in the barrier database file. Figure 6.12 shows the barrier database file, 'barrier.dat', which is located in the "WEPS1.0 Install" directory. This ASCII file may be edited (for NRCS only by designated qualified agronomists), using a standard text editor to add new barriers or modify parameters of existing barriers. The file separates barriers into various categories (i.e., TREES, SHRUBS, HERBACEOUS, etc.). However the user interface does not read nor display these barrier

Figure 6.12. Barrier database file "barrier.dat".

```
TREES
 Trees w/o leaves (1 row) |8|1|0.8|3
 Trees w/o leaves (2 row) |8|2|0.7|7
 Trees w/o leaves (4 row) |8|4|0.6|15
 Trees w/leaves(1 row)|8|1|0.6|3
 Trees w/ leaves (2 row) |8|2|0.5|7
 Trees w/leaves(4 row)|8|4|0.4|15
SHRUBS
 Shrubs w/o leaves (1 row) |2|1|0.7|2
 Shrubs w/o leaves (2 row) |2|2|0.5|5
 Shrubs w/ leaves (1 row) |2|1|0.5|2
 Shrubs w/leaves(2 row)|2|2|0.3|5
HERBACEOUS
 Grass Barrier (1 row) | 0.8 | 1 | 0.7 | 0.5
 Grass Barrier (2 row) | 0.8 | 2 | 0.5 | 1.0
CROP
 Kenaf(1 row) | 2.5 | 1 | 0.7 | 1
 Kenaf(2 row) | 2.5 | 2 | 0.5 | 2
 Sorghum (1 \text{ row}) | 2 | 1 | 0.7 | 1
 Sorghum(2 row)|2|2|0.5|2
 Flax(1 row) | 0.5 | 1 | 0.7 | 0.5
 Flax(2 row) | 0.5 | 2 | 0.5 | 1
 Corn(2 row) | 1.5 | 2 | 0.7 | 2
 Corn(3 row) | 1.5 | 2 | 0.6 | 3
 Corn(4 row)|1.5|2|0.5|4
 Wheat/Rye (1 \text{ row}) | 0.8 | 1 | 0.7 | 0.5
 Wheat/Rye (2 \text{ row}) | 0.8 | 2 | 0.6 | 0.6
 Wheat/Rye (3 \text{ row}) | 0.8 | 3 | 0.6 | 0.8
 Wheat/Rye (4 \text{ row}) | 0.8 | 4 | 0.5 | 1.0
 Wheat/Rye (1 \text{ row}) | 0.8 | 4 | 0.5 | 1.0
ARTIFICIAL
```

categories and they only serve as a visual aid within the database. Actual database values are in rows which begin with a blank in column one and each database parameter is separated by the pipe symbol, 'l'. The parameters are listed as follows: barrier name height (meters) | number of rows (not used) | porosity (fraction) | width (meters). Barrier height, width, and porosity were defined previously in this document. The barrier name is a character descriptor of the barrier and is the name displayed in the choice lists. The number of barrier rows parameter is not currently used by WEPS nor is it displayed in the interface. Once the barrier database file has been updated, restart WEPS and the new barrier and/or modified parameter values should appear in the barrier drop down list on the WEPS user interface.



Strip Cropping (Field Design)

Introduction

Dividing large fields into smaller fields is a design practice that often aids in controlling both wind and water erosion. The main effect achieved by reducing field size for wind erosion control is to reduce the amount of damaging abrader composed of saltating aggregates that impact immobile clod or crust surfaces as well as to reduce the breakage of the mobile saltation and creep aggregates. Reducing abrader permits the surface to become armored with immobile material, as the loose soil is removed or moved into a sheltered area on rough surfaces. However, merely reducing field size with strips provides only a small amount of wind erosion reduction on fields that lack significant amounts of clods, crust, growing biomass, or residues. Reducing abrader is also important for seedling protection. The Wind Erosion Prediction System (WEPS) provides a means of evaluating the effectiveness of strip cropping in reducing wind erosion. The objectives of this guide are to provide an overview of the effects of field size on wind erosion as simulated in the WEPS model and suggest some possible field designs to enhance wind erosion control. Examples using WEPS to evaluate strip cropping scenarios are also provided.

One method to accomplish a reduction in field size is to divide large fields into alternating strips. This practice is referred to as strip cropping, and an example is illustrated in Figure 6.1. In low rainfall areas, one-half the strips may be fallowed on alternate years. In other areas, one-half the strips may be producing low residue crops. Comparison of Figure 1a and Figure 1b illustrate important differences between the large fallow field and the same field when farmed in strips. On the large field, both moving soil and snow are removed. In contrast, when strip-cropped, part of the moving soil and snow are typically trapped in the next strip, and this results in a gain in both moisture and soil on portions of the stripped field. Using WEPS, the saltation/creep crossing eroding strip boundaries may be used to estimate the soil gain on adjacent non-eroding strips.

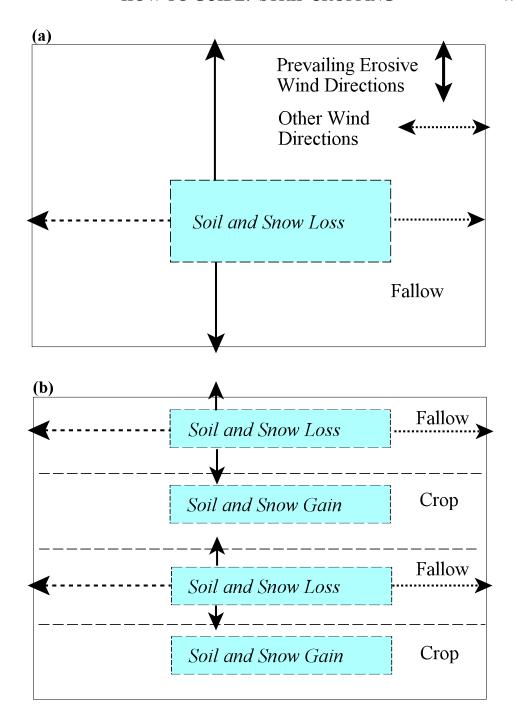


Figure 6.1. Comparison of (a) large fallow field and (b) the same field strip cropped with alternating crop and fallow strips.

Effects of Field Scale on Wind Erosion

The erosion processes in WEPS are simulated for an initially uniform field, and these include: emission (entrainment) of loose soil, abrasion of immobile clods/crusts, breakage of saltation/creep-size aggregates to suspension-size, and trapping of saltation/creep-size aggregates in sheltered depressions between clods, ridges, and plants or residues (Fig. 6.2). If standing biomass is present, a reduction of wind drag at the soil surface and biomass interception of mobile aggregates are also simulated. Using these processes, the model simulates a horizontal discharge (i.e., amount removed up to a downwind distance) of mobile saltation/creep (Fig. 6.3) and suspension-size aggregates (Fig. 6.4). On long erodible fields the saltation/creep discharge may reach transport capacity. Transport capacity is defined as the maximum horizontal discharge of saltation/creep possible for a given wind speed and surface condition. At transport capacity, the deposition of saltation/creep from the air stream per unit area equals the amount entrained into the air stream. Generally, there is still a net removal of saltation/creep aggregates from the surface to replace those lost by breakage to suspension-size. In this case, saltation-creep can only approach transport capacity. In contrast, the suspended discharge is not limited by transport capacity, since these particles continually diffuse into the atmosphere. Consequently, the mass of suspended material increases over the entire length of eroding fields, with the rate of increase controlled by the erosion processes.

Emission of clods/crust Suspension Discharge Saltation/creep

Top of control volume (diffusion zone)

Figure 6.2. Wind erosion processes on a bare field simulated in WEPS.

Trapping

Discharge

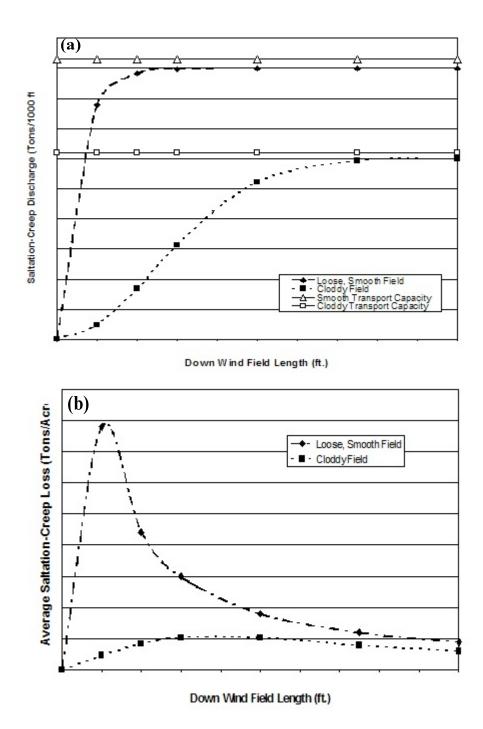


Figure 6.3. Comparison of (a) downwind discharge per 100 ft. of border width and (b) average soil loss for saltation-creep.

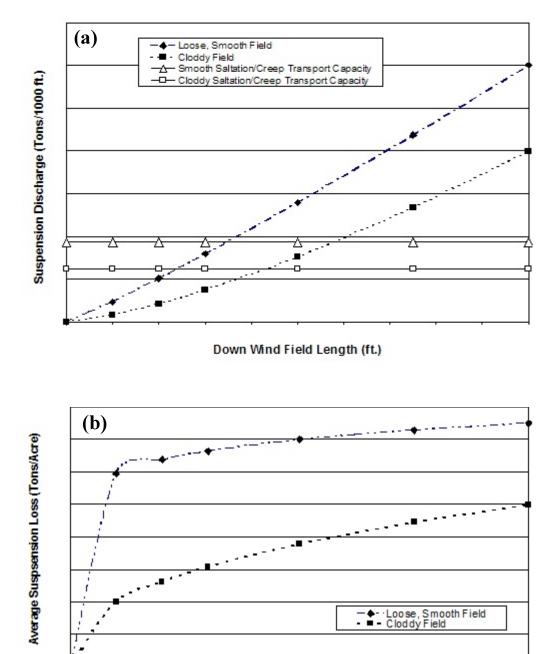


Figure 6.4. Downwind (a) discharge per 100 ft. of border width and (b) average soil loss of suspended soil.

Down Wind Field Length (ft.)

Conservation planners often design control systems based on average soil loss (i.e., amount removed per area). Total horizontal discharge at any downwind distance divided by the upwind field length represents the average soil loss over the upwind area. Using this calculation, one can illustrate the effects of varying field length on soil loss. Depending upon field surface conditions, the erosion processes cause differing patterns of horizontal soil discharge and consequently, differing soil loss for the saltation/creep-size (Fig. 6.3) and the suspension-size soil (Fig. 6.4). After saltation/creep reaches transport capacity, dividing the nearly-constant transport capacity by field length to give average soil loss shows there is a steady decrease in loss per unit area with increasing field length (i.e., area increases while transport remains essentially the same). In contrast, there is generally a large net loss of suspension-size soil over the entire field length. Total soil loss for any field length is determined by adding the average suspension and saltation/creep soil losses (Fig. 6.5). Generally, the maximum average soil loss occurs at a field length where both the saltation/creep and suspension components are contributing significant net soil loss. On far downwind portions of long fields, the increases in the soil discharge comes mainly from suspended soil, so the average soil loss may decrease somewhat with field length. Thus, on long fields, suspension soil loss typically exceeds the saltation/creep loss. Of course, if the mobile soil is composed mainly of sand larger than suspension-size (> 0.1 mm diameter), then saltation/creep will remain the dominant form of soil loss.

Smooth, loose fields often have a length where there is a maximum soil loss and the average loss then decreases beyond that field length (Fig. 6.5a). In this case, very short field lengths are necessary to control wind erosion. Thus, on all fields subject to wind erosion, planners should consider using other erosion controls in combination with strip cropping.

Suspended soil lost from long eroding fields can be considerable and is subject to long-range transport. Other detrimental effects also accompany this soil loss. These include an increase in sorting of the initial soil so that the removed soil is enriched in nutrients, organic matter, clay and silt fractions- the productive elements of the soil. The increased abrasion and breakage processes on long fields also increase the PM10 content (particulate matter <10 microns diameter) that is regulated as a health hazard. Thus, not only the amount, but also the quality and size distribution of the removed soil, changes as field length increases.

For simplicity, the Wind Erosion Equation (WEQ) predicts that average soil loss on long fields approaches a constant value. On the other hand in WEPS, the average soil loss may increase or decrease on long fields depending on whether creep/saltation or suspension is the dominant transport mode. Both the WEPS and WEQ models show that for effective erosion control, the field length along the prevailing wind erosion direction needs to be significantly less than the distance to the point of maximum soil loss. However, the effect of reducing field length on erosion is not linear, but varies approximately with the logarithm of the distance to transport capacity.

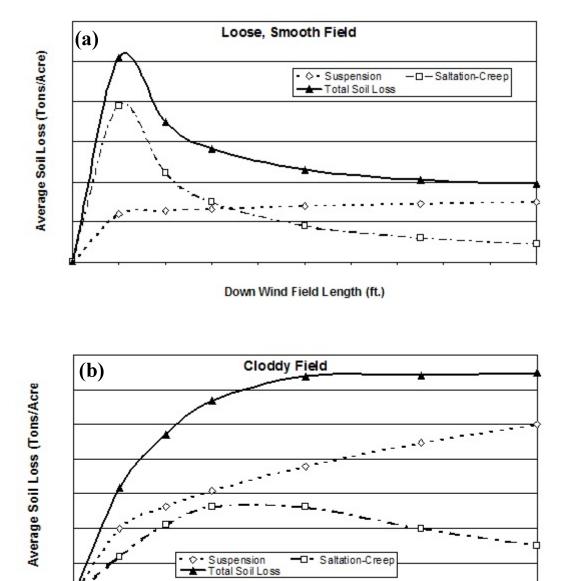


Figure 6.5. Comparison of average soil loss at various downwind distances on (a) a smooth, loose field and (b) a cloddy field.

Down Wind Field Length (ft.)

Designs to Enhance Erosion Control

On highly erodible fields or fields with inclusions of highly erodible soil, conventional strip crop systems such as that shown in Figure 6.1b, may not provide the needed level of erosion control. It is then the task of those designing erosion controls to recommend additional measures. Fortunately, there are a number of ways to enhance a strip crop system in order to provide additional levels of control, and several of these are illustrated.

One control option is to reduce the strip width in critical areas (Fig. 6.6). Wind erosion often begins within areas of a field that include a soil highly susceptible to wind erosion or in areas exposed to accelerated wind speeds. Saltating aggregates from these areas abrade downwind areas and break down immobile clods and crusts and thus, increase erodibility of the entire downwind area. On stripped fields there is potential to cover part of the problem area with a protective crop every year and thereby reduce the source area. In addition, the downwind area subject to abrasion may also be reduced. One may estimate the effect of strip width on these problem areas by choosing a soil representative of the problem area in the WEPS simulation.

A second option to reduce effective strip width is to employ wind barriers (Fig. 6.7). Correctly oriented barriers serve to shelter part of the erosive strip (Fig. 6.7a). They may also be used to divide the erosive strips to trap moving soil and further reduce the unsheltered lengths (Fig. 6.7b). If the barriers are short in height, relative to the unsheltered distance (e.g., herbaceous barriers), the latter design will reduce the unsheltered length by about one-half. When barriers or cross-wind strips trap moving saltation/creep, they effectively create a new non-erodible (stable) boundary. WEPS evaluates field conditions on each individual strip or field interval between barriers. Therefore, various field designs can be easily evaluated in WEPS by changing the field strip width and adding appropriate wind barriers as model inputs.

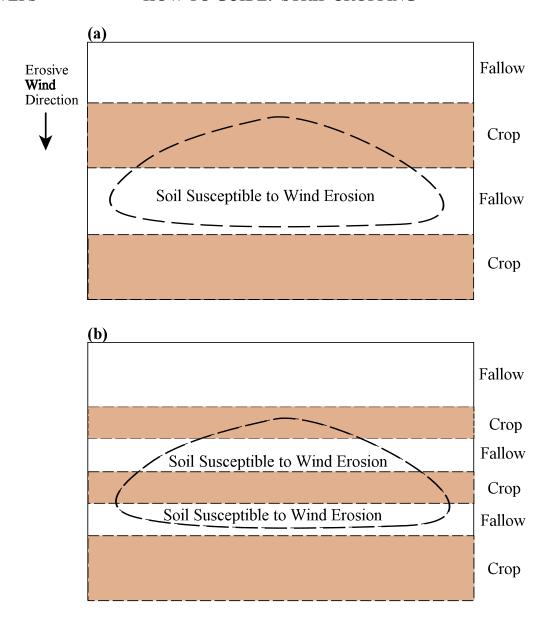


Figure 6.6. Erosion control designs illustrating (a) strips on erodible soils and (b) using narrow strips in critical areas with soils highly susceptible to wind erosion.

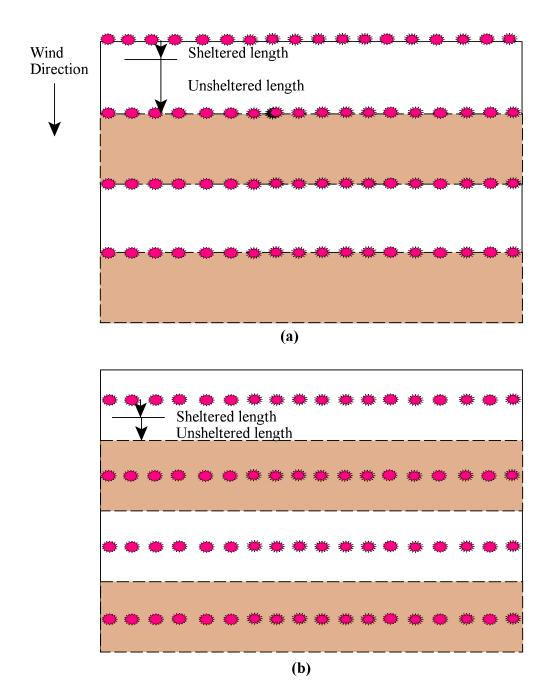


Figure 6.7. Erosion control designs using wind barriers (a) on strip borders and (b) in the middle of all strips.

Another option to enhance strip effectiveness is to employ surface roughness such as tillage ridges (Fig. 6.8). Adding tillage ridges provides additional trapping capacity for mobile soil (Fig. 6.8a). But it is often useful to orient ridges so they are not parallel to the long side of the strip as this provides some erosion control when wind directions are parallel to the strip (Fig. 6.8b). As a starting point, consider orienting ridges about 30 degrees from parallel to the strip and along the direction of the least erosive winds during critical wind erosion periods. For example, in Figure 8b, we assumed that the southeast-northwest winds were less erosive than southwest-northeast winds. WEPS can be used to help optimize design of these systems by comparing various tillage directions.

Other options are particularly useful when there are erosive winds parallel to conventional strips. These options include avoiding long, straight tillage ridges (Fig. 6.9a). Saltation along the furrows parallel to tillage ridges often undercuts the ridge crust which lowers the ridge effectiveness and leaves an accumulation of mobile material. Periodically changing ridge direction can provide sheltered accumulation zones for saltating soil. Furrow diking is also highly effective in reducing saltation/creep parallel to ridges. Field strips may also be designed with curvature (Fig. 6.9b and Fig. 6.10). In terraced farming systems, curvature of strips is usually a necessity, but the practice can often be useful in other systems. The curvature of the strip provides trapping areas for eroding soil moving along a given wind direction. WEPS can be used to evaluate these systems by inputting the strip width and then estimating the length between zones where saltation/creep material is trapped.

In summary, strip cropping is most effective when appropriate strip width and orientation are determined and combined with other wind erosion control practices such as maintaining a rough, cloddy surface and residue cover.

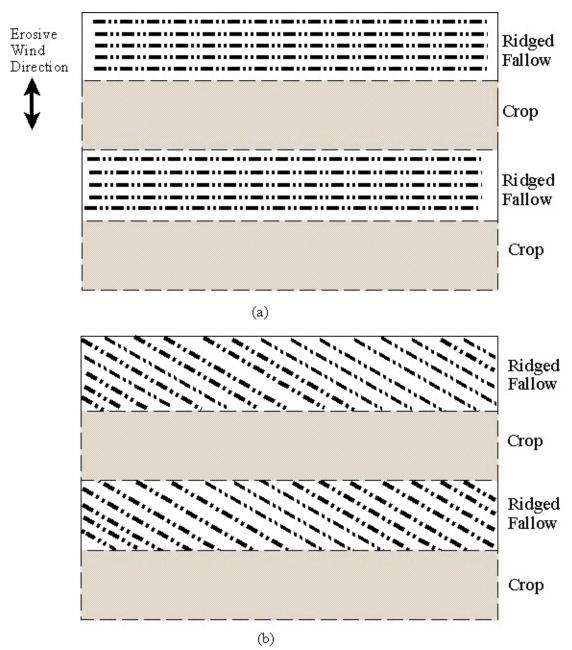


Figure 6.8. Designs using (a) parallel tillage ridges and (b) angled tillage ridges.

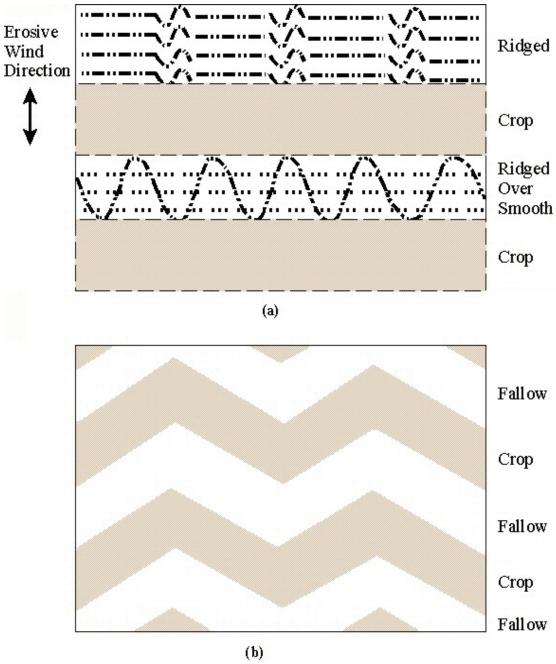


Figure 6.9. Erosion control designs using (a) variations of curved ridges and (b) curved strips.



Figure 6.10. Example of field strips designed with curvature.

Examples of Strip Cropping Using WEPS

The WEPS model can be used to evaluate strip cropping for the reduction of soil loss by wind. Here, some example simulation runs are provided, which illustrate the procedure and effectiveness of breaking up a large field into narrow strips.

No Strip Cropping

The beginning scenario for this example (Fig. 6.11) is defined as follows:

- Farm is located near Saint Francis in Cheyenne County, Kansas
- Soil is silt loam
- ▶ Wheat-fallow rotation as shown in the MCREW screen (Fig. 6.12)
- Field size of 2640' x 2640', 160 acres
- ► No barriers, 0.0 degree field orientation (North-South)

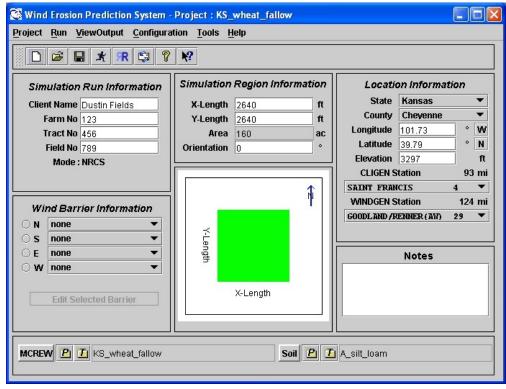


Figure 6.11. Main screen showing setup for non-strip cropped field.

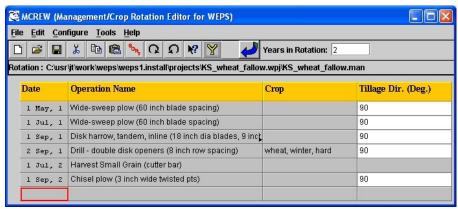


Figure 6.12. Management Crop Rotation Editor for a conventional wheat fallow rotation.

As can be seen in the Project Summary Report (Fig. 6.<u>13</u>), the simulation run for this non-strip cropped scenario resulted in an annual average soil loss of 21.2 tons /acre/year, with 26.9 tons/acre/year lost during the first year (fallow) of the rotation and 15.4 tons/acre/year lost during the second year (wheat) of the rotation. Note that since no barriers are present

to affect loss across the field, the gross loss is equal to the net soil loss for the field. In addition, the amount of creep/saltation and suspension soil loss are presented. Notice that the suspension made up a majority of the field and boundary loss (Fig. 6.14) on the non-stripped field because the field was probably wide enough to allow creep/saltation to approach transport capacity and suspension material to continually diffuse into the atmosphere (Figs. 6.3 and 6.4).

The soil loss in this scenario would generally be considered an unacceptable amount and conservation measures should be recommended. To determine if strip cropping would be effective, the user should first view the Boundary Loss summary report for the non-stripped field as shown in Figure 6.14. In this case, almost all of the eroding soil mass is crossing the south and east field boundaries, indicating northerly and westerly prevailing wind directions. Since most of the mass is crossing the southern field border, dividing the field in east-west oriented strips will shorten the field length in the direction having the most loss.

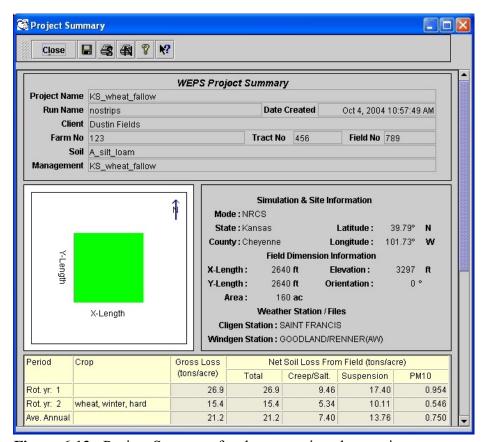


Figure 6.13. Project Summary for the non-stripped scenario.

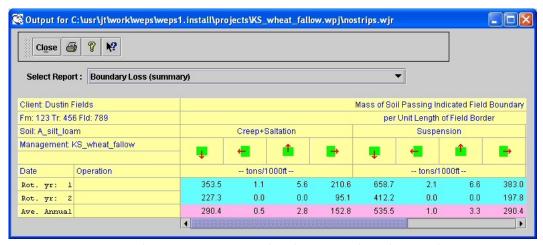


Figure 6.14. Boundary Loss summary for the non-stripped scenario.

Strip Crop

In an attempt to reduce soil loss along the direction having the greatest loss, the field is divided into eight, 330 foot wide strips (20 rods each) with strips alternating the wheat and fallow part of the rotation (Fig. 6. 15). The strips are oriented with the long sides aligned eastwest. We simulate one strip of the field, with the wheat fallow management rotation. All other conditions remain the same as the original non-stripped field.

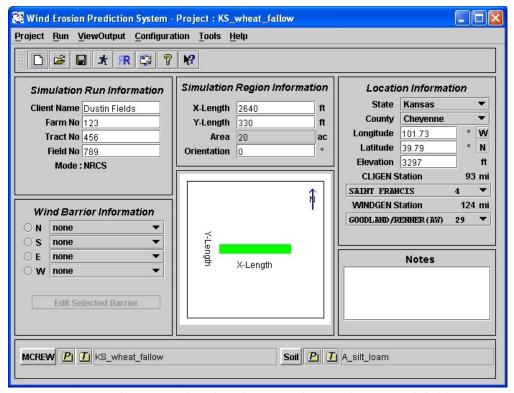


Figure 6.15. Main screen showing the setup for a strip cropped field.

As can be seen in the Project Summary Report (Fig. 6.<u>16</u>), breaking the field into strips reduced the annual average soil loss to 1.7 tons/acre/year, with 2.1 tons/acre/year lost during the first year (fallow) of the rotation and 1.4 tons/acre/year lost during the second year (wheat) of the rotation. Since loss is reported on a per acre basis, the loss for the strip represents the loss rate per acre for the entire field.

The Project Summary report also shows that suspension loss was less than the creep/saltation loss on the stripped field. Recall that suspension made up a majority of the loss on the non-stripped field (Fig. 6.13). Since the processes of creep/saltation increase downwind, an increasing amount of suspension is generated (Figs. 6.3 and 6.4). Limiting the field length therefore, limits these suspension generating processes.

On stripped fields, creep/saltation sized aggregates will be deposited within the alternating strips that have adequate wheat or residue cover to stop the movement. This deposition of creep/saltation material in adjacent strips is not modeled within WEPS but can be estimated from creep/saltation crossing the strip boundaries and should be considered in control strategies.

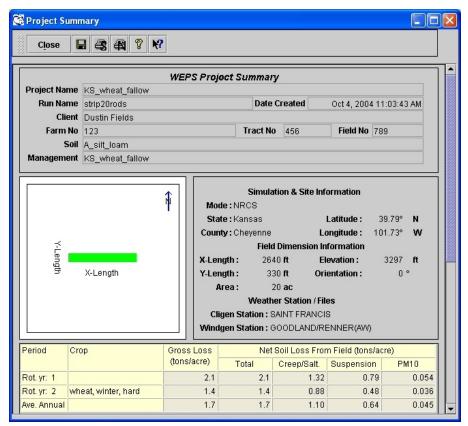


Figure 6.16. Project Summary report for the strip cropped scenario.

The Boundary Loss summary (Fig. $6.\underline{17}$) shows that, although field length was unchanged in the east-west direction, a significant reduction in loss still occurred on the eastern boundary. This indicates that much of the original soil loss on the eastern boundary was the result of winds that were not directly out of the west. Therefore, some winds deviated from the westerly direction, causing soil loss across the east boundary. As a result of this deviation, stripping the field provided some reduction in field length along the wind direction, resulting in a reduction of soil loss in the eastern direction.

Although the Boundary Loss for creep/saltation generally stays on the field within the adjacent strip, suspension boundary loss can potentially leave the field area. Therefore the suspension boundary loss should be multiplied by the number of strips to determine total suspension boundary loss for the total 160 acre field. This applies to the long sides of the strips, but not to the ends of the strips.

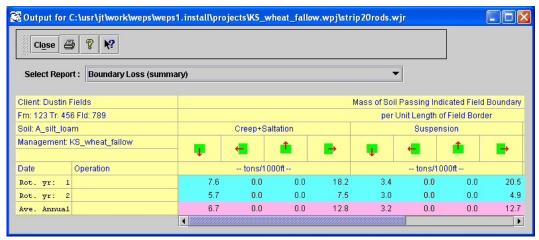


Figure 6.17. Boundary Loss summary for the strip cropped scenario.

Strip Crop with Grass Barriers

Even though stripping the field significantly reduced erosion rates, additional reduction can be obtained by adding a herbaceous barrier between the strips. An example of strip cropping with herbaceous barriers is illustrated in Figure $6.\underline{18}$ and the WEPS main screen setup for this scenario is shown in Figure $6.\underline{19}$. In this example we added a one row grass barrier on each side of the strip (height = 3.0 ft., width = 1.6 ft., and porosity = 0.3).



Figure 6.18. Example of field, strip cropped with herbaceous barriers.

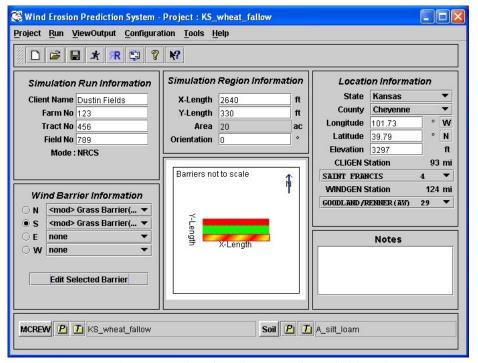


Figure 6.19. Main screen showing the setup for a field, strip cropped with grass barriers.

As can be seen by the Project Summary (Fig. 6.20), adding a barrier on each side of the strip further reduced average gross loss for the rotation to 0.9 tons/acre/year. The loss for first year (fallow) of the rotation was reduced to 1.2 and for the second year (wheat) it was reduced to 0.6 tons/acre/year. Note in this scenario that since barriers are present, the net loss is less than the gross soil loss for the field. This difference is due to deposition that occurs just before the downwind barrier. The net creep/saltation was reduced to 0.18 tons/acre/year and suspension was reduces to 0.28 tons/acre/year. Again, creep/saltation deposition in adjacent strips is not modeled within WEPS. Since almost no creep/saltation is available to generate suspension size material one can conclude that most of the suspension is from loose suspension sized material on the surface.

The boundary loss for this scenario is shown is Figure 6.21. Both creep/saltation and suspension leaving the field were significantly reduced on the south boundary compared to the stripped without barrier case. Loss on the eastern boundary was only slightly reduced compared to the stripped without barriers.

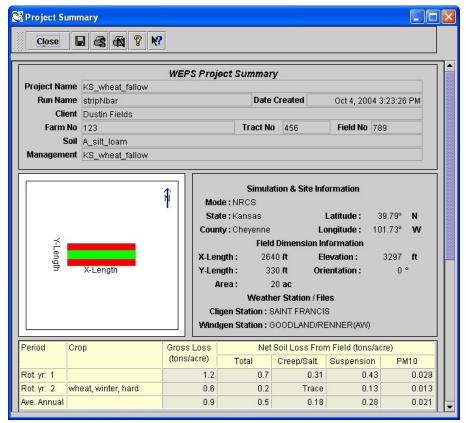


Figure 6.20. Project Summary report for the strip cropped with barriers scenario.

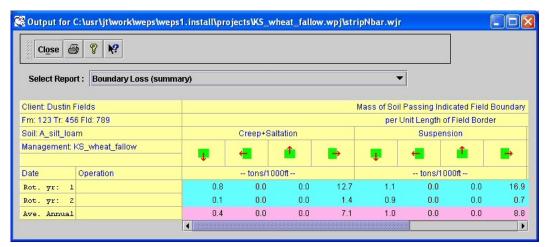


Figure 6.21. Boundary Loss summary for the strip cropped with barriers scenario.

Considerations When Strip Cropping on Highly Erodible Soil

This set of examples contain field and management conditions that are the same as the previous examples except that the soil is a highly erodible, loamy sand. The Project Summary for the non-stripped scenario (Fig. 6.22) indicates an annual average loss of 96.0 tons/acre/year with and average of greater than 150 tons/acre/year being lost in the first year (wheat) of the rotation. Note the net loss for creep/saltation is 22.53 tons/acre/year and suspension is 73.40 tons/acre/year. Again, the boundary loss (Fig. 6.23) shows that the most loss passes the southern boundary and so shortening the field in the north-south direction by stripping is a control strategy that should be considered.

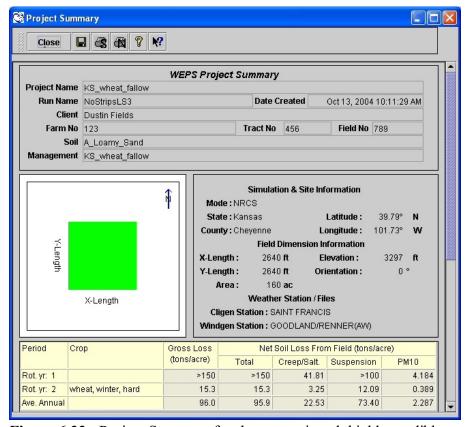


Figure 6.22. Project Summary for the non-stripped, highly erodible scenario.

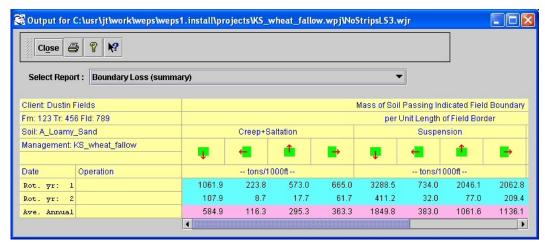


Figure 6.23. Boundary Loss summary for the non-stripped, highly erodible field.

To observe the effects of strip width on this highly erodible soil, we begin with a field divided into thirty two, 82 feet wide strips (5 rods each) with the long sides aligned in the east-west direction in an attempt to reduce soil loss. All other conditions for the field remain constant for the simulation. We continue to successively double the width of the strips (i.e., 82, 165, 330, 660, 1320, 2640 ft.) and simulate the soil loss as strips get wider. The results of these simulations are shown in Table 6.4 and indicate that average annual total loss continually increases with increases in the strip width. The net creep/saltation loss however, shows an increase as width increases from the narrow stripped scenario to a maximum loss at 660 ft width. As widths become wider than 660 ft., the creep/saltation loss decreases.

Table 6.4. Change in soil loss with changing strip width.

Strip Width		Average Net Loss from Field (tons/acre/year)			South Boundary Loss (tons/1000 ft.)	
feet	rods	Total	Creep/Salt.	Suspension	Creep/Salt.	Suspension
82	5	35.1	25.77	10.31	32.6	10.6
165	10	48.9	33.67	15.24	84.6	33.5
330	20	68.1	43.13	24.99	204.4	111.1
660	40	88.7	46.23	42.46	404.2	359.8
1320	80	95.1	34.52	60.59	539.4	917.8
2640 (no strip)	160	95.9	22.53	73.40	584.9	1849.8

To discuss these changes in loss with field length, it is important to recall that the term "loss" refers to the amount of removal per area of the field. The term "discharge" refers to the amount of material removed per width across the field.

The initial increase in creep/saltation loss, as a highly erodible fields get wider (Table 6.4), is a result of large increases in discharge relative to small increases in field area (i.e., left part of curve in Figure 6.3a and 6.3b for the loose, smooth field). However at some point down wind on wide fields, the creep/saltation discharge reaches transport capacity where loss and deposition are equal (i.e., where Figure 6.3a becomes nearly flat for the loose, smooth field). Thus an increase in field width from that point does not result in any further net discharge of creep/saltation size material (Fig. 6.3a) and actually shows a decrease in loss of

creep/saltation material as strips get wider (Fig. 6.3b and 6.5a). This decrease in loss as strips get wider, occurs because net loss is calculated by dividing the constant discharge (transport capacity) by the increasing area (tons/acre). This decrease in creep/saltation loss as wide fields get wider may under some field conditions, even occur with the total net loss from the field. In the present case however, even though the creep/saltation rate increased as wide strips got narrower, the suspension was continually reduced. The reduction in suspension was more than enough to compensate for the increase in creep/saltation and thus the total loss rate was reduced as strip width decreased.

It is very important to note that the boundary loss for the south boundary (Table 6.4) shows a significant reduction in both the creep/saltation and suspension leaving the field as width decreases. Notice that there was not an increase in boundary loss of creep/saltation with field distance on wide strips as there was with the field loss. This is because boundary loss is divided by a constant distance (tons/1000 ft) as strips get wider. The boundary loss represents the amount leaving the field boundary and illustrates the value of dividing the field into strips to control erosion by wind especially on highly erodible fields.

Adding a grass barrier on each side of a 330 ft strip, as in the previous example, further reduces soil loss over the similar size strip without barriers (Fig. 6.24). Total gross loss was reduced to 21.2 tons/acre/year. Note that again the net loss was cut almost in half because of deposition just before the downwind barrier within the simulated strip. However, this erosion rate is still unacceptable and much more aggressive control strategies should be examined. More aggressive residue retention with a stubble mulch system will be attempted next.

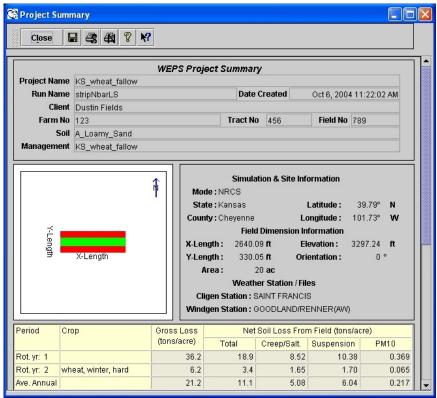


Figure 6.24. Project Summary for the strip cropped, highly erodible scenario with barriers.

Finally, to further reduce erosion loss the management used on the previous example is changed to a stubble mulch system designed to retain more crop residue throughout the rotation. The modified management is shown in Figure 6.25 and was created by delaying the sweep operations and eliminating a chisel operation in the fall of the second year.

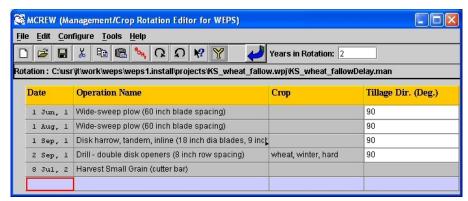


Figure 6.25. Management Crop Rotation Editor for a conventional wheat fallow rotation.

Switching to a stubble mulch in addition to a grass barrier on each side of a 330 ft strip, as in the previous example, further reduces gross soil loss to 7.0 tons/acre/year on the highly erodible field. The net loss however was reduced to 3.8 tons/acre/year (Fig. 6.26). Note that again the net loss was cut almost in half because of deposition just before the downwind barrier within the simulated strip. However, this erosion rate is still unacceptable and more intensive control strategies should be examined. To reduce loss even further, more aggressive residue retention should be tried or even the retirement of the land into permanent grass should be a possible consideration.

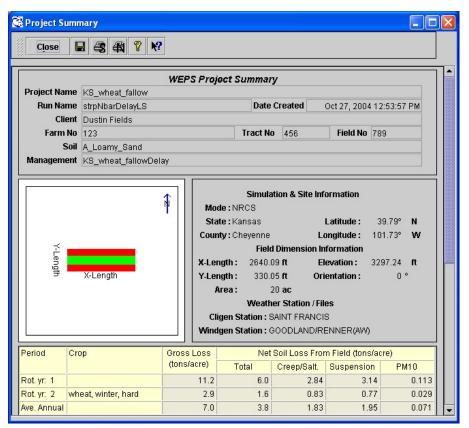


Figure 6.26. Project Summary for the strip cropped with barriers and a stubble mulch management system.



Crop Database Record Development

Introduction

In the plant growth submodel of the Wind Erosion Prediction System (WEPS), biomass is converted from solar radiation and partitioned to root and shoot parts (Fig. 6.1). The shoot mass is partitioned into leaf, stem, and reproductive masses. Finally the reproductive mass is partitioned into grain and chaff parts. Development of the crop in WEPS is a function of the heat unit index, which is the ratio of the heat units (growing degree days) at any time during the growing season to the total amount of heat units required to grow a crop from planting to maturity. The heat unit index is 0 at planting and the crop reaches maturity when the heat unit index is 1.

To perform these and other operations, crop growth in WEPS is configured by a set of parameters that define and drive the growth processes represented in the model code. Reasonable crop growth in different environments is achieved by setting the appropriate parameter values for the type of crop being grown. The purpose of this guide is to define and describe the process of obtaining reasonable parameter values based on knowledge of crop characteristics.

After estimating a parameter value, specific WEPS output can be examined to see if the parameter setting gives reasonable results. Not all WEPS output is available through the WEPS interface output reports. Therefore, the user is sometimes referred to other output files, such as 'crop.out' which contains daily output for many crop variables and 'decomp.out', which contains daily output for many decomposition variables. A parameter should be adjusted if a related simulated variable does not look reasonable. After adjusting the parameter(s), run WEPS again and inspect the variable again to see if it matches what is expected. If not, continue to adjust the parameter values on this trial and error basis. Be sure to look at simulation output for more than one growing season.

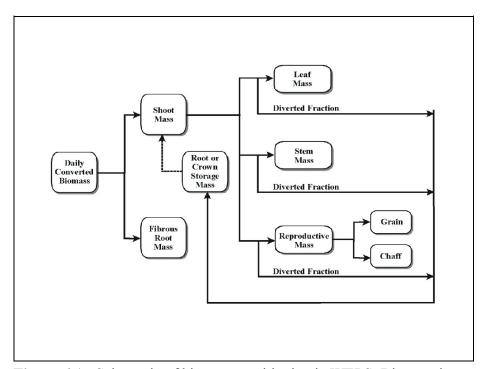


Figure 6.1. Schematic of biomass partitioning in WEPS. Biomass is converted from solar radiation and partitioned to 'fibrous root' and 'shoot' parts. The shoot mass is partitioned into leaf, stem, and reproductive masses, with some fraction of these masses diverted into a storage pool for crop regrowth. Finally the reproductive mass is partitioned into grain and chaff parts.

Crop Database Structure Files and Definitions

Crop database records are stored in an XML format file with the extension .crop for use by the WEPS interface. Supporting files which define the database structure are part of the MCREW configuration files. New individual crop database records are most directly created using MCREW to edit an existing crop file and saving it to a new name. New files can also be created using a text editor to edit the .crop file directly. The parameter descriptions below provide the keys to enable the reader to know which parameter he is editing using either method.

The parameters are defined below with units and are identified by a **Parameter Prompt**, which is the text that appears in the MCREW Crop drill down screen. Some parameters have **Parameter Choices**, which is a list of choices that will be displayed when the parameter is defined as a discrete set of values, often integer flags. The parameters are grouped according

to similar function just as they are grouped by tabs on the Crop Drill Down screen. Some parameters have both primary and alternate units which along with a conversion factor, are given in Table 6 4.

Table 6.4. Parameters having both primary and alternate units. The WEPS science model uses the primary units. Alternate units are used if English units are selected in the WEPS configuration. To convert from primary units to alternate units multiply by the given conversion factor (and add 32 where indicated).

Parameter Prompt	Primary Units	Alternate Units	Conversion Factor
Plant population	#/m ²	#/acre	4046.7
Planted mass, dry weight	mg/plant	ounce/plant	3.5274*10 ⁻⁵
Root storage mass required for each regrowth shoot	mg/shoot	ounce/shoot	3.5274*10 ⁻⁵
Heat units to maturity	°C day	°F day	1.8
Minimum temperature for plant growth	°C	°F	1.8 + 32
Optimum temperature for plant growth	°C	°F	1.8 + 32
Maximum growth diameter of a single plant	m	ft	3.281
Residue : Yield intercept	kg/m ²	lb/acre	8921.8
Maximum root depth	m	ft	3.2808
Maximum crop height	m	ft	3.2808
Lower temperature	°C	°F	1.8 + 32
Higher temperature	°C	°F	1.8 + 32
Stalk diameter	m	inches	39.3696
Mass to cover factor	m ² /kg	acre/lb	0.00011209

Crop Parameter Definitions

Shoot Tab

The emergence of plant shoots, from either seeds, stored root mass, or the pseudo emergence of transplants is controlled by four crop parameters: "Planted mass, dry weight", m_p , "Root storage mass required for each regrowth shoot", m_{sh} , "Ratio of leaf mass/stem mass in shoot", r_{ls} , "Ratio of stem diameter to stem length", r_{dl} , and two parameters described later in this document: "Stem silhouette area coefficient a" and "Stem silhouette area coefficient b". Note that the "Root storage mass required for each regrowth shoot" is mostly used in regrowth calculations. If the "Planted mass, dry weight" is greater than the "Root storage mass required for each regrowth shoot", then multiple shoots per plant will be generated. The number of shoots per plant, n_{sh} , which will grow from the planted (stored) mass, is calculated from:

$$n_{sh} = \max \left[1, \min \left[n_{ms}, \frac{m_p}{m_{sh}} \right] \right]$$

$$N_{sh} = N_p n_{sh}$$
(6.5)

where n_{ms} is the "Maximum number of shoots per plant" and N_{sh} is the number of shoots per square meter. Note that n_{sh} does not have to be an integer. The shoot growth subroutines assume a 70% conversion efficiency from stored to live biomass. When growth is from seed or a transplant, 40% of growth biomass will become roots. The stem length at full extension is calculated as:

$$m_{st} = \frac{0.7(1 - 0.4)m_p}{(r_s + 1)}$$

$$A_{st} = a \left(\frac{m_{st}}{10^6} \frac{N_{sh}}{N_p}\right)^b \frac{N_p}{N_{sh}}$$

$$l_{st} = \sqrt{\frac{A_{st}}{r_{st}}}$$
(6.6)

where m_{st} is the mass of stem generated in the complete emergence process, A_{st} is the silhouette area of a single stem, and l_{st} is the length of stem generated at full extension. Full extension has been realized when all of the planted (stored) mass (m_p) has been converted to generated shoot mass. Emergence occurs when l_{st} is greater than the "Starting depth of growing point". An error message is generated if emergence never occurs.

Parameter Prompt: Crop Type

Parameter Choices: 1 - Warm season legume (soybeans, etc.)

- 2 Cool season legume (peas, etc.)3 Perennial Legume (alfalfa, etc.)
- 4 Spring Seeded and Warm Season Annuals (spring wheat, cotton, sunflowers, corn, etc.)
- 5 Cold Season Annuals (winter wheat, winter canola)
- 6 Perennials (pasture, etc.)

This selection determines crop growth processes, such as vernalization (crop types 2 and 5 implement a vernalization delay to overwinter heat unit accumulation), and the ability to regrow after cutting (crop types 3 and 6 will regrow if sufficient root or crown storage has been accumulated).

Parameter Prompt: Transplant or Seed flag
Parameter Choices: 0 - Seeds planted in field

1 - Transplants planted in field (mass immediately divided into root, leaf, stem).

This flag is set to indicate that plant growth begins with a transplant or with a seed being placed in the field. If growth begins with a transplant (as opposed to grown from seed) a number of additional parameters need to be adjusted: the length of the growing season will need to be shortened, either days or heat units to represent the time from transplant to maturity; the planted mass, dry weight, to represent the size of the transplant; and the heat unit index at (pseudo) emergence, to represent a reasonable transplant shock recovery time.

Parameter Prompt: Plant population, N_p (#/m²)

The number of plants expected in a normal stand. This should be the estimated plant population after germination. If the maximum number of shoots per plant (next parameter) is set to one, then this is the total number of stems expected.

Parameter Prompt: Maximum number of shoots per plant, n_{ms} (#/plant)

Growth of multiple shoots occurs when this value is greater than one and root (crown) storage mass is greater than "Root storage mass required for each regrowth shoot" at the time regrowth commences. The number of stems produced can be examined by viewing the number of stems per square meter (the variable '#stems' in the output file 'crop.out') and comparing it to the "Plant Population" (previous parameter).

Parameter Prompt: Starting depth of growing point (m)

Crop growth begins at this depth in the soil. Root extension proceeds downward

from this depth while shoot extension proceeds upward from this depth at equal rates. It is necessary that the shoot growth parameters below result in a shoot length greater than this depth or seedlings will not emerge. This depth is used as the depth from which regrowth begins for crop types 3 and 6 at all times. For crop types 1 and 4, the growing point is moved to the surface at the completion of seedling emergence. For crop types 2 and 5, the growing point is moved to the surface after the initiation of spring growth.

Parameter Prompt: Planted mass, dry weight, m_p (mg/plant)

At planting time, total plant biomass is initialized to this value. From the time of growth initialization until the completion of emergence, this mass is allocated to roots, stems, and leaves. For a crop grown from a seed, the mass should be set to the individual seed weight. For a crop that is placed in the field as a transplant, the total plant dry weight, including roots, should be entered.

Parameter Prompt: Root storage mass required for each regrowth shoot, m_{sh} (mg/shoot)

As described above, the number of shoots that grow from stored root mass is calculated based on this parameter. For crops that can regrow from stored root or crown mass, this value is used, along with the "Maximum number of shoots per plant" and the stored root mass of the crop to determine how many shoots will re-sprout. The partitioning of mass to be stored for regrowth is set using the parameters "Fraction of leaf mass partitioning diverted to root storage", "Fraction of stem mass partitioning diverted to root storage", and "Fraction of standing store mass partitioning diverted to root storage". The quantity stored varies depending on growth conditions.

Parameter Prompt: Ratio of leaf mass/stem mass in shoot, r_{ls}

This is the ratio at full extension. When the growth of a shoot from stored mass occurs, as in germination, regrowth after cutting, or the pseudo growth used to initialize a transplant, mass is divided into leaf and stem using this ratio. This value should be large enough to generate the leaf area required to get crop growth started. If a crop does not grow adequately, examine the variable 'eff_lai' in the output file 'crop.out'. It should show a value of 0.01 or greater at the heat unit index at emergence.

Parameter Prompt: Ratio of stem diameter to stem length, r_{dl}

This is the ratio at full extension. When the growth of a shoot from stored mass occurs, as in germination, regrowth after cutting, or the pseudo growth used to initialize a transplant, stem length is calculated from stem mass using this ratio. This parameter is the prime candidate for adjustment to insure that plant emergence occurs when growing from seed.

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Parameter Prompt: Heat unit index at emergence

Setting this value to zero will cause the program to fail.

Growth Tab

Parameter Prompt: Crop maturity measurement method

Parameter Choices: 0 - Crop matures on average in Days shown

1 - Crop matures in Heat Units shown

For some types of crops, corn being the best example, the length of the growing season is genetically manipulated and the average length of the crop growth period for that area is expressed in days, not heat units. When this option is set to 0, the average weather for the location being simulated is used to find the heat unit accumulation from the planting day through the number of days shown in the "Days to maturity" parameter. The simulation is then run using this heat unit total as the season length. For option 1, the value entered for "Heat units to maturity" is used directly, regardless of location. Because of the effect of vernalization on the calculation of average heat units is not implemented, all crop types 2 and 5 should be configured to use option 1.

Parameter Prompt: Days to maturity (days)

For annual grain crops, the average number of days from planting to maturity of seed; for vegetable, fruit and root crops, sugarcane, and tobacco it is the number of days from planting (or ratooning) to harvest; for perennials (e.g. alfalfa) it is the number of days from spring growth to maturity of seed.

Parameter Prompt: Heat units to maturity (°C day)

For annual grain crops, the average seasonal heat units from planting to maturity of seed; for vegetable, fruit and root crops, sugarcane, and tobacco it is the average seasonal heat units from planting (or ratooning) to harvest; for perennials (e.g. alfalfa) it is the average seasonal heat units from spring growth to maturity of seed.

Parameter Prompt: Heat unit index at start of senescence

This is the fraction of the growing season (expressed as heat unit index) when plant senescence begins. Examine the variable 'eff_lai' in the output file 'crop.out' to see the effect of adjusting this parameter.

Parameter Prompt: Minimum temperature for plant growth (°C)

The average daily air temperature below which the model will not allow plant growth (full temperature stress). This is commonly know as the minimum cardinal growth temperature and forms the base temperature for calculating heat unit accumulation.

Parameter Prompt: Optimum temperature for plant growth (°C)

The average daily air temperature at which the model will allow maximum growth (no temperature stress). This is commonly know as the maximum cardinal growth temperature and forms the upper temperature for calculating heat unit accumulation. When the daily air temperature exceeds this value, heat units accumulate at the maximum rate for the day and temperature stress increases.

Geometry Tab

Parameter Prompt: Maximum growth diameter (m) of a single plant

Some cropping systems use plant densities that do not result in canopy closure. In these systems, the plant will grow to cover a ground area that is characteristic of the plant. WEPS assumes that the covered ground area is round. This parameter is the diameter of the circle that encloses the covered area. Biomass production is reduced by the decrease in intercepted light (some of the light reaches the soil), unless the reduced densities are used to reduce water stress for the remaining plants.

Parameter Prompt: Stem silhouette area coefficient a

Parameter Prompt: Stem silhouette area coefficient b

For many crops, the relationship of stem silhouette area to its mass is described well by a 2-parameter power function, which is used to compute stem silhouette area from stem mass: $SSA = a M^b$, where SSA is stem silhouette area (m² / plant), M is stem mass (kg / plant), and a and b are coefficients. Retta and Armbrust (1995) obtained values for alfalfa, corn, sorghum, oat, winter wheat, and soybean.

Parameter Prompt: Specific leaf area (m² / kg)

For many crops the relationship of leaf area to its mass is described well by a linear relationship, which is used to compute leaf area from leaf mass: LA = a M, where LA is leaf area (m² / plant), M is leaf mass (kg / plant), and a is specific leaf area (m² / kg).

Parameter Prompt: Light extinction coefficient

Canopy light utilization is specified by an exponential relationship for the attenuation of light with distance into the canopy. Combined with the leaf area index, this coefficient determines the amount of light interception by the canopy according to the relationship:

$$fraction = 1 - \exp^{-k LAI}$$
 (6.7)

where fraction is the ratio of photosynthetically active radiation (PAR) that is

intercepted by the crop and total PAR received above the crop canopy, k is light extinction coefficient, and LAI is leaf area index (Fig. 6.2). A higher number indicates increased light interception by a given leaf area index, as occurs with broadleaf plants with a horizontal leaf orientation, such as cotton. A lower number indicates decreased light interception by a given leaf area index, as occurs with narrow leaf plants with a vertical leaf orientation such as the grasses.

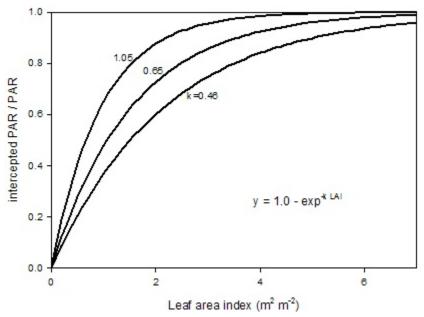


Figure 6.2. Relationship between leaf area index and fraction of light intercepted (intercepted PAR / PAR) for three different values of the light extinction coefficient k. WEPS uses k=1.05 for cotton; k=0.65 for corn, soybean, potato and sugar beet; and k=0.46 for sorghum and millet.

Parameter Prompt: Biomass Conversion Efficiency (t/ha) / (MJ/m²)

The unstressed (potential) growth rate per unit of intercepted photosynthetically active radiation. EPIC values were used as a starting point for the major crops. Literature searches revealed that this value is difficult to measure exactly.

Partitioning Tab

The daily converted (grown) biomass is partitioned between root and shoot mass (Figure $6.\underline{1}$). The shoot mass (above ground biomass) is further partitioned into leaf, stem, and

reproductive mass (Figure 6.3). Both the leaf curve and the reproductive curve are defined by a 4-parameter function. The remaining mass is considered stem mass. The three fractions always add to 1.0.

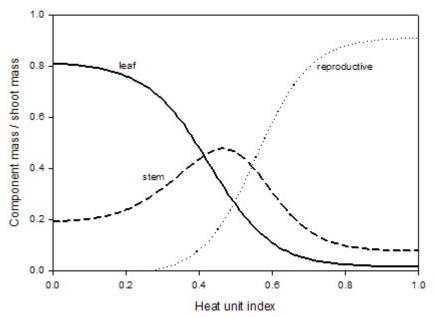


Figure 6.3. Partitioning of shoot mass (above ground biomass) into component mass for winter wheat. Components are leaf, stem, and reproductive mass. By definition, these three fractions always add to 1.0.

Specify the four parameters for the leaf curve (Figure 6.4):

Parameter Prompt: Leaf fraction coefficient a The lower asymptote.

Parameter Prompt: Leaf fraction coefficient b

The range between the upper and lower asymptote.

Parameter Prompt: Leaf fraction coefficient c

The heat unit index at the inflection point. The leaf mass / shoot mass ratio at the inflection point is half way between the lower and upper asymptote (a + b/2).

Parameter Prompt: Leaf fraction coefficient d

Determines the slope of the curve. A negative d produces a descending curve (leaf)

and a positive d gives an ascending curve (reproductive).

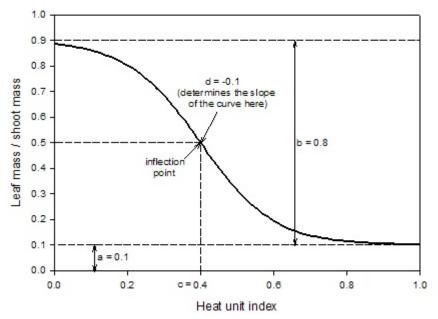


Figure 6.4. Partitioning of shoot mass into leaf mass. In this example, a = 0.1, b = 0.8, c = 0.4, and d = -0.1. The leaf mass / shoot mass ratio at the inflection point = a + b/2 = 0.5.

Specify the four parameters for the reproductive curve:

Parameter Prompt: Reproductive mass coefficient a The lower asymptote.

Parameter Prompt: Reproductive mass coefficient b

The range between the upper and lower asymptote.

Parameter Prompt: Reproductive mass coefficient c The heat unit index at the inflection point.

Parameter Prompt: Reproductive mass coefficient d
Determines the slope of the curve at the inflection point.

For a new crop, the four leaf parameters can be adjusted based on total leaf mass development (the variable 'total leaf' in the output file 'crop.out'). Check total stem mass development by inspecting the variable 'total stem' in the output file 'crop.out'. If stem mass development seems unsatisfactory, adjust both leaf and reproductive parameters to change

the stem partitioning curve.

Reproductive mass should be equal to zero before time of flowering. This may be used as a point on the reproductive partitioning curve. Inspect the variable 'standing store' in the output file 'crop.out'. If 'standing store' is greater than zero before flowering is expected, partitioning to reproductive mass starts too early in the growing season. Adjust the reproductive parameters accordingly.

By default (option Y1), WEPS does not use the reproductive parameters. WEPS will only use them if the Y0 option is specified. If using the reproductive parameters for partitioning then harvest index is also something to look at. Adjust partitioning parameters if the harvest index seems incorrect. Remember that adjusting leaf and/or reproductive parameters will automatically affect stem mass partitioning.

The default method for partitioning and to calculate crop yield from total above ground biomass uses the two parameters below to specify the relationship between yield and residue, where yield plus residue equals total above ground biomass. The equation is:

$$residue = r \times yield + b \tag{6.8}$$

where b is the minimum above ground biomass required for a crop to generate any yield, and r is the incremental increase in residue for each additional unit of yield above the minimum. The two parameters were estimated for the major crops from field data gathered for this purpose.

Parameter Prompt: Residue : Yield ratio (kg/kg)

Parameter r. As defined for the equation above, this is the incremental increase in residue for each additional unit of yield above the minimum.

Parameter Prompt: Residue: Yield intercept (kg/m²)

Parameter b. As defined for the equation above, this is the minimum biomass required for a crop to generate any yield.

Biomass is stored in the root (or crown) storage pool based on the values of the following three parameters. They are tied to the three biomass partitioning components (leaf, stem, reproductive) of plant growth, allowing the modeling of plants which store biomass during different periods of the growing season (Fig. $6.\underline{1}$).

Parameter Prompt: Fraction of leaf mass partitioning diverted to root storage

For crops that store biomass early in the growth season, set this value greater than zero.

Parameter Prompt: Fraction of stem mass partitioning diverted to root storage For crops that store biomass in the middle of the growth season, set this value greater than zero.

Parameter Prompt: Fraction of reproductive mass partitioning diverted to root storage Crops that store biomass late in the growth season, set this value greater than zero. For root crops, this value should be very close to 1, indicating that most reproductive biomass is stored below ground.

Size Tab

Parameter Prompt: Maximum root depth (m)

The maximum depth of roots attained by the crop under ideal (unstressed) growth conditions. The main modeling impact of this value is the depth of soil water extraction. Examine the variable 'rootd' in the output file 'crop.out' to see the effect of adjusting this parameter.

Parameter Prompt: Maximum crop height (m)

The maximum height attained by the crop under ideal (unstressed) growth conditions. For a new crop, this parameter can be adjusted based on the crop height (the variable 'height' in the output file 'crop.out'). If WEPS simulates too high a crop (inspect 'height'), then decrease the parameter value. After adjustment, inspect the height variable again to see if it matches what is expected. If not, continue to adjust the parameter values on this trial and error basis. Be sure to look at simulation output for more than one growing season. Note that the crop height at the end of the growing season will usually be less than this maximum crop height. Only if the crop grows under unstressed conditions for the entire growing season will the crop height at the end of the season be equal to the maximum crop height.

Crop height development through the growing season, as it would be without any stresses (potential), is defined by a 2-parameter function (Figure 6.5). This curve should be in harmony with the partitioning curves discussed earlier, i.e. the greatest increase in plant height should coincide with the greatest stem partitioning ratio.

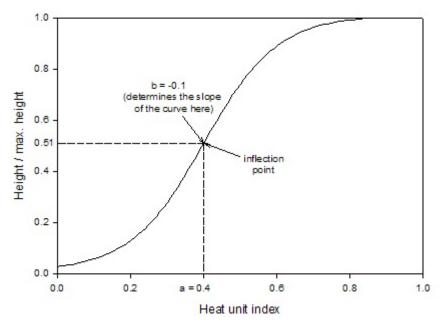


Figure 6.5. Crop height development function as it would be without any stresses. In this example, a = 0.4 and b = -0.1. The height ratio at the inflection point = 0.51.

Specify the two parameters for the crop height development curve (Figure 6.5):

Parameter Prompt: Crop height coefficient a

The heat unit index at the inflection point.

Parameter Prompt: Crop height coefficient b

Determines the slope of the curve at the inflection point. A negative b produces an ascending curve.

For a new crop, the two parameters above can be adjusted based on the crop height (the variable 'height' in the output file 'crop.out'). If WEPS simulates too high a crop too early in the growing season (inspect 'height'), then increase the "a" parameter value. If WEPS simulates too gradual a crop height increase (inspect 'height'), then increase the "b" parameter value (make b less negative). Changing a and/or b may result in the final crop height to change. This can be adjusted by changing the maximum plant height.

Cold Tab

In WEPS, freezing temperatures can reduce green leaf area. This reduction is calculated from a curve (Figure $6.\underline{6}$). For example, using Figure $6.\underline{6}$, if the daily minimum temperature of the top soil layer equals -15 °C, the green leaf area is reduced by 95% on this day.

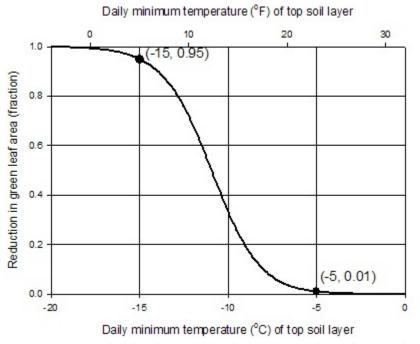


Figure 6.6. Reduction in green leaf area due to frost damage for corn.

The user can specify the frost damage curve by specifying two points on the curve. The curve for corn in Figure $6.\underline{6}$ is specified by the points (-5, 0.01) and (-15, 0.95). Use the Excel spreadsheet to visualize the curve after specifying two points on the curve. The following four parameters specify the two points:

Parameter Prompt: Higher temperature (°C)
This is -5 °C (23 °F) for the example in Figure 6.6.

Parameter Prompt: Reduction in green leaf area at higher temperature This is 0.01 (1%) for the example in Figure 6.6.

Parameter Prompt: Lower temperature (°C)
This is -15 °C (5 °F) for the example in Figure 6.6.

Parameter Prompt: Reduction in green leaf area at lower temperature This is 0.95 (95%) for the example in Figure 6.6.

For a new crop, the four parameters above can be adjusted based on the green leaf area (the variable 'eff lai' in the output file 'crop.out'). Example: the new crop is a winter crop. If WEPS simulates too much reduction in green leaf area over the winter (inspect eff lai), then adjust the four parameter values so that there is less reduction in green leaf area for the same freezing temperatures.

Parameter Prompt: Thermal delay coefficient pre-vernalization

For winter annual crops (crop types 2 and 5), the rate of heat unit accumulation is reduced if the plants have not been exposed to cool temperatures. The method implemented is from Ritchie, J.T. (1991). For crops which do not experience vernalization, the value is set to 0.0. A crop requiring a high degree of vernalization would have a value around 0.04. Examine the variable 'hu del' in the output file 'crop.out' to see the effect of adjusting this parameter. This variable is 0.0 when vernalization has not yet started and it is 1.0 when the crop is fully vernalized.

Harvest Tab

Parameter Prompt: Which plant component is (partially) harvested?

- Parameter Choices: 0 constant fraction of reproductive mass (grain+)
 - 1 increasing fraction of reproductive mass (grain)
 - 2 all or fraction of aboveground biomass
 - 3 all or fraction of the leaf mass
 - 4 all or fraction of the stem mass
 - 5 all or fraction of underground mass

Crop harvesting operations remove parts of plants which are not explicitly specified as a plant part in the model. To compensate for this, a mass fraction can be specified (see "Harvested fraction of plant component" below) to divide the plant component into harvested fraction (fraction removed from the field) and fraction left in the field. For example, the reproductive component of wheat is divided into grain and chaff during harvest and only the grain is removed from the field. This entry specifies the plant component which will be divided if that plant component is harvested. Choice 1 specifies a type of crop where early season reproductive development is all chaff and awns, not grain. If the crop is harvested before maturity, grain development is incomplete. Internally, the model increases the actual harvested fraction from zero early in the season, until the value entered in "Harvested fraction of plant component" is reached at maturity.

Examples:

- 0 Stripper cotton, where all the reproductive mass is removed from the field. In this case, the "Harvested fraction of plant component" for this example would be set to 1 Expression of final yield in bales of lint then requires accounting for the amount of trash and seed in the yield conversion factor below;
- 1 harvested grains, such as wheat, oats, barley, milo, corn. For a crop like corn, ear corn would have a higher value for the "Harvested fraction of plant component" than shelled corn, where the cob is left in the field;
- 2 hay or forage crops, green vegetable crops. The "Harvested fraction of plant component" in most cases would be 1.0, indicating that all aboveground biomass above the cutting height is removed from the field. It should be less than 1.0 for a crop where significant portions of the aboveground biomass above the cutting height are left behind in the field. This comment also applied to choices 3 and 4.
- 3 tobacco and similar crops;
- 4 Sugarcane and similar crops;
- 5 Potatoes, peanuts, sugar beets.

In all cases, this setting and the corresponding "Yield fraction of harvested yield component" should be used to divide mass removed from mass left in the field, NOT mass removed from mass actually counted as yield. The "Harvested yield conversion factor" (see below) should be used to account for post harvest processing into marketable components.

Parameter Prompt: Harvested fraction of plant component (grain fraction etc.)

See "Which plant component is (partially) harvested" for a full explanation.

Parameter Prompt: Units for reporting harvested yield

This field contains the units label that will be displayed for yield reporting. It should match the "Harvested yield conversion factor (kg/m² to units shown)" value that is entered below.

Parameter Prompt: Moisture content for reporting harvested yield (%)

In WEPS, all biomass values are tracked as oven dry weight. Crop yields are normally reported at a "standard" moisture content other than oven dry weight. For yield reporting, oven dry weight is converted to the moisture content entered in this field. To match yield numbers from other sources, this value should be the "standard" moisture content used for this product.

Parameter Prompt: Harvested yield conversion factor (kg/m² to units shown)

This parameter should match the "Units for reporting harvested yield" value that is entered above. The conversion factor is applied to the WEPS internal yield amount

units (which is in kilograms per square meter) to report the yield in the units which are specified. This conversion is applied directly to the material removed from the field, as defined in "Which plant component is (partially) harvested?" and "Harvested fraction of plant component" and implemented by the appropriate harvest operation. If the component removed from the field is post processed into a marketable product and a byproduct, and the yield reported in units of marketable product (cotton lint yield is an excellent example), the fraction of marketable product should be included in this conversion factor.

Decomposition Tab

For a better understanding of the decomposition parameters, also consult the Residue Decomposition Sub-model technical documentation.

Parameter Prompt: Residue size/toughness class

Parameter Choices: 1 - Fragile, very small residue, e.g. soybeans

2 - Moderately tough, short residue, e.g. wheat

3 - Non fragile, medium residue, e.g. corn

4 - Woody, large residue (sticks, hard wood)

5 - Gravel, rock

This class is used to determine what percentage of residue should be buried by certain management operations. For example, a tillage operation such as disking will bury a higher percentage of small, fragile residue and a lower percentage of large, woody residue.

Parameter Prompt: Decomposition days after which stalks begin to fall (day)

The Number of days after which stalks begin to fall under optimum moisture and temperature conditions. After this threshold has been reached, stalks will begin to fall at the rate discussed below. Example: a threshold of 20 decomposition days means that standing stalks begin to fall 20 days after harvest if moisture and temperature conditions are optimum during these 20 days. If conditions are not optimum the number of days that stalks remain standing increases.

For a new crop, this parameter can be adjusted based on the number of stalks in residue pool 1 (the variable 'stem1' in the output file 'decomp.out'). Example: the new crop is a winter crop that is harvested in July. It is known that on average stalks begin to fall down in the middle of October. If WEPS simulates that stalks begin to fall down only in the next Spring (inspect stem1), then decrease the parameter value to start stem fall earlier. Increase the parameter value if WEPS makes the stalks fall too early.

Parameter Prompt: Fall rate for standing stalks (day⁻¹)

The rate at which standing stalks fall to a flattened (horizontal) position on the soil surface. A greater number means that stalks fall faster. Only after a threshold has been reached (see above), stalks will begin to fall at this rate. Example: a fall rate of 0.12 day⁻¹ means that 12% of the total number of standing stalks fall down per day if moisture and temperature conditions are optimum on this day. If conditions are not optimum the fall rate is reduced.

For a new crop, this parameter can be adjusted based on the number of stalks in residue pool 1 (the variable 'stem1' in the output file 'decomp.out'). Example: the new crop is a winter crop that is harvested in July. There is a fallow period of 14 months in which it is known that on average 50% of the stalks fall down. If WEPS simulates that less than 50% falls down (inspect stem1), then increase the parameter value to increase stem fall. Decrease the parameter value if WEPS makes the stalks fall too fast. Adjust 'Decomposition days after which stalks begin to fall' (see above) before adjusting this parameter.

Parameter Prompt: Decomposition rate for standing stalks (kg kg⁻¹ day⁻¹)

The rate at which standing stalks decompose under optimum conditions. A greater number means faster decomposition. Example: a decomposition rate of 0.02 kg kg⁻¹ day⁻¹ means a 2% standing stalk mass loss per day if moisture and temperature conditions are optimum for decomposition on this day. If conditions are not optimum, the rate is reduced. Leaves, if any are present, decompose at 3 times the rate of stalks and reproductive material, if any is present, decomposes at 1.5 times the rate of stalks. Other models, such as WEPP and RUSLE, simulate the effect of moisture and temperature on decomposition differently from WEPS (see WEPS technical documentation). Thus, the same parameter value results in different rates of decomposition. Therefore, if a new WEPS crop already exists in one of these other models, this parameter value cannot be used in WEPS.

For a new crop, this parameter can be adjusted based on the amount of standing residue biomass in residue pool 1 (the variable 'stand1' in the output file 'decomp.out'). Be sure to only look at this variable before stalks start falling. After stalks start falling, stand1 decreases due to two things: decomposition and stem fall. Example: the new crop is a winter crop that is harvested in July. It is known that on average stalks begin to fall down in the middle of the next April. Inspect stand1 between July and April. If stand1 is decreasing too rapidly, then decrease the parameter value. Increase the parameter value if stand1 decreases too slowly.

Parameter Prompt: Decomposition rate for surface (flat) stalks (kg kg⁻¹ day⁻¹)

The decomposition rate (under optimum conditions) of stalks that have fallen to a flattened (horizontal) position on the soil surface. For a new crop, this parameter can

be adjusted based on the amount of flat residue biomass in residue pool 1 (the variable 'flat1' in the output file 'decomp.out'). Be sure to only look at this variable before stalks start falling. After stalks start falling, flat1 is affected by two things: decomposition and stem fall. It will actually increase if the mass received from the standing pool exceeds the flat mass that is decomposed. Example: the new crop is a winter crop that is harvested in July. It is known that on average stalks begin to fall down in the middle of the next April. Inspect flat1 between July and April. If flat1 is decreasing too rapidly, then decrease the parameter value. Increase the parameter value if flat1 decreases too slowly.

Parameter Prompt: Decomposition rate for buried stalks (kg kg⁻¹ day⁻¹)

The decomposition rate (under optimum conditions) of stalks that have been buried below the soil surface by tillage. For a new crop, this parameter can be adjusted based on the amount of buried residue biomass in residue pool 1 (the variable 'belo1' in the output file 'decomp.out').

Parameter Prompt: Decomposition rate for roots (kg kg⁻¹ day⁻¹)

The rate at which roots decompose under optimum conditions. For a new crop, this parameter can be adjusted based on the amount of root residue biomass in residue pool 1 (the variable 'root1' in the output file 'decomp.out').

Currently in WEPS, the four parameters above (decomposition rate parameters for standing, flat, buried and root mass) have the same values for a given crop. It is recommended to also do this for new crops, unless there is solid research data to do otherwise. For the six parameters above, be sure to look at a no-till situation, since tillage operations will also make stalks fall down.

Parameter Prompt: Stalk diameter (m)

Stalk diameter at the base (at the soil surface) of a fully grown plant.

Parameter Prompt: Mass to cover factor (m² kg⁻¹)

WEPS calculates soil cover from flat residue mass:

$$C_f = 1 - \exp^{-b M_f} ag{6.9}$$

where C_f is flat residue cover (m² m⁻²), b is mass to cover factor (m² kg⁻¹), and M_f is flat residue mass (kg m⁻²) (Figure 6.7).

Use the Excel spreadsheet to estimate a b value for a new crop, comparing with curves for crops that already exist in WEPS. If reliable mass and cover data are available for the new crop, the spreadsheet can be used to calculate a b value from this data.

RUSLE also uses the equation above to calculate soil cover from flat residue mass. Therefore, if a new WEPS crop already exists in RUSLE, and there is a high degree of confidence in the value of the RUSLE b parameter, this value could be used in WEPS.

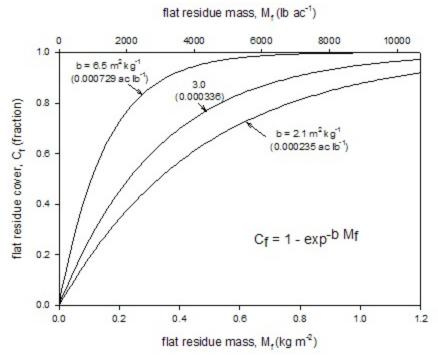


Figure 6.7. Relationship between flat residue mass and the cover provided by this flat residue for three different values of the mass to cover factor b. WEPS uses $b = 6.5 \text{ m}^2 \text{ kg}^{-1}$ for wheat, barley, oats, rye and triticale; $b = 3.0 \text{ m}^2 \text{ kg}^{-1}$ for corn, sorghum and millet; and $b = 2.1 \text{ m}^2 \text{ kg}^{-1}$ for cotton and sunflower.

Crop residue laying flat on the soil surface has the effect of reducing the water evaporation rate from the soil surface. Research done by Steiner (1989) showed that the effect varied for different crops. The data from the paper for, cotton, sorghum and wheat, was refit to an exponential power relationship

$$r_{\varepsilon} = \exp^{\left(a_{\varepsilon} M_{f}^{\delta_{\varepsilon}}\right)} \tag{6.10}$$

where r_e is the ratio of evaporation from residue covered soil to bare soil evaporation and M_f is flat mass (kg/m²). This equation has better mathematical properties than the curve used in the paper. If additional research is available, intermediate curves can be developed using the spreadsheet "howtopcropdb.xls" on the "evaporation suppression" tab. Otherwise, use the numbers for the crop that most closely characterizes the evaporation suppression

characteristics of the crop you are developing.

Parameter Prompt: Residue Evaporation Suppression multiplier coefficient a

Parameter Prompt: Residue Evaporation Suppression multiplier coefficient b

Calibration Tab

Parameter Prompt: Crop growth calibration selection
Parameter Choices: 0 - Crop NOT selected for calibration

1 - Select Crop for calibration to match target harvested yield

This flag is only effective when the model is run in calibration mode. It should be set to zero for all crop records.

Parameter Prompt: Target harvested yield

This value is only used when the model is run in calibration mode. It should be set to 0 for all crop records.

Parameter Prompt: Biomass adjustment factor

Multiplier used with biomass conversion efficiency (see below) to enhance or suppress the conversion of solar radiation to biomass. This is the factor that is automatically adjusted when calibrating a crop. When developing a new crop record, this value should be set to 1.0.

Parameter Prompt: Yield/biomass ratio adjustment factor

Intended use has not been implemented. Was to allow adjusting the ratio between total yield and total biomass for calibration purposes. Set to 1.0 for all crop records.

References

- Retta, A. And D.V. Armbrust. 1995. Estimation of Leaf and Stem Area in the Win d Erosion Prediction System (WEPS). Agron. J. 87:93-98.
- Ritchie, J.T. 1991. Wheat Phasic development. *In*: Hanks, J. and Ritchie, J.T. eds. Modeling plant and soil systems. Agronomy Monograph 31, pages 34-36.
- Steiner, J.L. 1989. Tillage and Surface Residue Effects on Evaporation from soils. Soil Sci. Soc. Am. J. 53:911-916.